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The Imperial Mineral Resources Bureau.

IT will be remembered that as a result of the deliberations of the Imperial War Conference last year a Special Committee, under the chairmanship of Sir James Stevenson, was appointed by Dr. Addison, then Minister of Munitions, to prepare a scheme for the establishment, in London, of an Imperial Mineral Resources Bureau. The proposal that the Committee was asked to examine was, that a Bureau should be formed to collect information from Government Departments and other sources in regard to the mineral resources and metal requirements of the Empire, and that it should advise what action, if any, might appear desirable to enable such resources to be developed and made available.

The Committee reported at the end of July, 1917, and recommended the formation of a Bureau with the following duties:—

1. To collect, co-ordinate, and disseminate information in regard to the resources, production, treatment, consumption, and requirements of every mineral and metal of economic value.

2. To ascertain the scope of the existing agencies, with a view ultimately to avoid any unnecessary overlapping that may prevail.

3. To devise means whereby the existing agencies may, if necessary, be improved and assisted in the accomplishment of their respective tasks.

4. To supplement those agencies, if necessary, in order to obtain any information not now collected which may be required for the Bureau.

5. To advise on the development of the mineral resources of the Empire, or of particular parts of it, in order that such resources may be made available for Imperial defence or industry.

After the consideration of the report the Government instructed the Minister of Reconstruction, in consultation with the Secretaries of State for the Colonies and India, to give effect to the findings of the Committee. As these provided that the administration of the Bureau was to be controlled by a governing body representing the various parts of the Empire as well as the mineral and metal industries, detailed proposals were submitted to the Dominion and Indian Governments, who nominated their representatives; while the remaining members of the governing body were nominated by the Minister of Reconstruction in consultation with the Institution of Mining and Metallurgy, the Institute of Metals, the Iron and Steel Institute, and the Institute of Mining Engineers. This constitution was ratified by the Imperial War Conference which met in London this year.

The Bureau will be incorporated by Royal Charter, and the governing body, which will be under the presidency of the Lord

President of the Council, will have the following constitution:—Chairman: Sir Richard Redmayne, representing the United Kingdom; and the following members: Dr. Willet G. Miller, representing Canada; Mr. W. S. Robinson, Australia; Mr. T. Hutchinson Hamer, New Zealand; The Rt. Hon. W. P. Schreiner, the Union of South Africa; The Rt. Hon. Lord Morris, Newfoundland; Mr. R. D. Oldham, India; Dr. J. W. Evans, Crown Colonies; Mr. W. Forster Brown (Mineral Advisor to H.M. Woods and Forests); Professor H. C. H. Carpenter (President of the Institute of Metals); Dr. F. H. Hatch (Member of the Mineral Resources Advisory Committee of the Imperial Institute and Past President of the Institution of Mining and Metallurgy); Sir Lionel Phillips (late Director of the Mineral Resources Development Department, Ministry of Munitions); Mr. Edgar Taylor (of John Taylor & Son, and late President of the Institution of Mining and Metallurgy); Mr. Wallace Thorneycroft (President of the Institution of Mining Engineers). Mr. Arnold D. McNair is Secretary, and the offices of the Bureau are for the present at the Holborn Viaduct Hotel, E.C.

Some department such as this has long been needed, and it is to be hoped that the new body will fulfil the expectations that have been aroused by its appointment, and that its functions will not be restricted to the collection and dissemination of information, but that it will also institute such researches as may appear desirable as to the occurrence of important but little-known minerals, both in this country and in the Colonies. The exigences of the War have shown how important for the welfare of the State the discovery of new sources of such minerals may become; examples will occur to everyone. In the present war the cutting off of overseas supplies has necessitated the search for and development of home resources of manganese, wolfram, iron pyrites, phosphates, petroleum, etc. This country has been well served in the past by its purely scientific institutions, but the economic side has been unduly neglected. We wish the Bureau a successful career in the important work assigned to it.

ORIGINAL ARTICLES.

I.—On the Distribution of the British Carboniferous Goniatites, with a description of one New Genus and some New Species.

By Wheelton Hind, M.D., B.S., F.R.C.S., F.G.S.

(PLATE XVI.)

PART III of the Catalogue of the Fossil Cephalopoda in the British Museum (Nat. Hist.), by A. H. Foord and G. C. Crick, was published in 1897. Since then much fresh material has come into my hands and it is now possible to give much more accurate and fuller details of the horizons and localities at which the various species occur. This is of special importance, in view of the fact that the Goniatites can be used as zone indices of the Carboniferous Series from the upper part of the *Dibunophyllum* beds (D_2 of Dr. Vaughan)

up to the Middle Coal-measures. This I showed to be the case in my Presidential address to the Yorkshire Naturalists' Union, and published in the *Naturalist*, April to July, 1909, and elsewhere. Many details have, however, been added since then, and an elaborated and emended table will be published in a forthcoming paper by myself and Dr. Wilmore, F.G.S., on the Carboniferous succession of some Midland areas.

The zones published in the *Yorkshire Naturalist*, op. supra cit., p. 154, were as follows:—

Millstone Grits . .	*Gastrioceras listeri*.
Pendleside Series . .	*Glyphioceras bilingue*.
	G. spirale.
	G. reticulatum.
	Posidonomya becheri.
	Cyathaxonia.
Carboniferous Limestone.	Upper *Dibunophyllum*.

It may be briefly stated that the Goniatites mentioned above occur with the utmost regularity wherever these horizons are exposed. Of the zones in the above list the *G. reticulatum* zone is the least satisfactory, on account of the persistence of the species from Pendleside to Middle Coal-measure times. Several other Goniatite zones will be indicated in the forthcoming paper, with greater detail as to their extent. Many of the localities given in the Museum Catalogue (op. supra cit.) are unsatisfactory, partly because, at the time when it was published, the zones of the Carboniferous rocks had not been made out, and partly because the real history of many of the specimens in the Natural History Museum was not known. Collections were largely referred to the town where the collectors lived, e.g. Halifax, Todmorden. Halifax is given as a locality for a large number of species which could not have come from the Lower Coal-measures. I suspect that many of these, if not all, came from the collection of the late J. W. Davis, of Halifax. I see this fact was mentioned by Mr. Crick, Q.J.G.S., vol. lxvii, pp. 400–4. Long lists of fossils are given by J. W. Davis in his portion of the volume, *West Yorkshire*, part i, Geology, 1878 (Davis and Lees), but none are referred to Halifax as a locality. The "Hardbed Coal" occurs there with the marine fossils of the Mountain Mine or Bullion Coal, and the locality is correct for *Gastrioceras listeri*, *G. carbonarium*, *Dimorphoceras gilbertsoni*, *D. looneyi*, and *D. discrepans*. The locality Halifax must therefore be called in question for all Goniatites other than the above. Todmorden is also unsatisfactory, for, though the Goniatite beds occur at that town, the majority of the collections have been made from Horsebridge Clough, Crimsworth Dean, and High Green Wood, north of Hebden Bridge, from the valley of Hebden Water and its tributary. The two former localities are in the same little valley.

The Natural History Museum is fortunate in possessing nearly all the types of Phillips's Goniatites, but the localities given by him are practically valueless. Bolland is a large district, partly in Lancashire, partly in Yorkshire, and practically the whole of the Lower Carboniferous rocks occur therein. Black Hall, near Chipping, and

some of the Devonshire Culm localities are, however, sufficiently detailed to determine the exact horizon. "River Ribble" is, of course, too vague. The Scottish localities are copied from the Handbook, Brit. Assoc., Glasgow, 1901, p. 503, where there is a list of Carboniferous Cephalopoda from the Clyde area, drawn up by J. Neilson. Many Devonshire localities are quoted from Mr. Crick's paper, Q.J.G.S., vol. lxvii, pp. 309–408.

Several Irish localities are quoted from Foord's Carb. Ceph., Ireland, part v, Pal. Soc., vol. lvii, 1903. Several Irish specimens which are known only from a single locality are not dealt with, because I have no knowledge of the exact horizon at which they occur. Unfortunately, it will be noted that all known British Goniatites occur in the upper beds of the Carboniferous Limestone and the succeeding series, and except in Ireland no Goniatites are noted from beds below the Upper *Dibunophyllum* zone. I suspect that Kniveton, however, will be eventually found to be of a much lower horizon, and there I have obtained species which I refer to *G. corpulentum*, M'Coy, and a variety of *G. truncatum*, and I possess a large specimen of this variety from Clitheroe. The presence at Kniveton of *Pericyclus fasciculatus* is interesting. De Koninck has described the following species: From Tournai—*Brancoceras rotatorius*, *Glyphioceras complanatus*, *G. rotella*, *G. ryckholti*, *G. crenulatus*, *G. perspectivus*, *G. belvalianus*, *Pericyclus divisus*, *P. funatus* (*princeps*). From Pauquys—*Glyphioceras inconstans*, *G. spheroidale*, M'Coy, *P. fasciculatus*. From Vève—*P. impressus*. At least four of the above species occur in Ireland.

TABLE OF DISTRIBUTION OF BRITISH GLYPHIOCERATIDÆ.

COAL-MEASURES . . .	*Glyphioceras reticulatum*, Phillips.
	G. micronotum, Phillips.
	Dimorphoceras gilbertsoni, Phillips.
	D. looneyi, Phillips.
	Gastrioceras listeri, Martin.
	G. carbonarius, V. Buch.
	G. coronatum, Foord & Crick.
	Nomismoceras ornatum, Foord & Crick.
MILLSTONE GRIT . .	*Pericyclus impressus*, de Koninck.
	P. divaricatum, Hind.
	Glyphioceras reticulatum, Phillips.
	G. beyrichianum, de Koninck.
	G. bilingue, Salter.
	G. calyx, Phillips.
	G. phillipsii, Foord & Crick.
	G. davisi, Foord & Crick.
	G. platylobum, Phillips.
	G. spirale (var.), Phillips.
	Dimorphoceras gilbertsoni, Phillips.
	D. looneyi, Phillips.
	D. discrepans, Brown.
	Gastrioceras listeri, Martin.
PENDLESIDE SERIES . .	*Glyphioceras reticulatum*, Phillips.
	G. bilingue, Salter.
	G. davisi, Foord & Crick.
	G. phillipsii, Foord & Crick.
	G. spirale, Phillips.

	G. beyrichianum, de Koninck.
	G. striolatum, Phillips.
	G. bidorsale, Phillips.
	G. calyx, Phillips.
	G. vesica, Phillips.
	G. nitidum, Phillips.
	G. platylobum, Phillips.
	Dimorphoceras gibsoni, Phillips.
	D. looneyi, Phillips.
	D. discrepans, Brown.
	Nomismoceras rotiforme, Phillips.
	N. spirorbis, Phillips.
	N. vittager, Phillips.
	Prolecanites serpentinus, Phillips.
	P. compressus, Sowerby.
Carboniferous Limestone (D_2 beds)	*Pericyclus funatus*, Sowerby.
	P. fasciculatus, M'Coy.
	P. doohylensis, Crick.
	Brancoceras enniskilleni, Foord.
	Glyphioceras crenistria, Phillips.
	G. striatum, Sowerby.
	G. sphæricum, Martin.
	G. fimbriatum, Foord & Crick.
	G. obtusum, Phillips.
	G. implicatum, Phillips.
	G. truncatum, Phillips.
	G. micronotum, Phillips.
	G. vesica, Phillips.
	G. mutabile, Phillips.
	G. excavatum, Phillips.
	C. vesiculifer, de Koninck.
	G. complicatum, de Koninck.
	Nomismoceras vittager, Phillips (very rare).
	Dimorphoceras gilbertsoni, Phillips.
	Prolecanites cyclolobus, Phillips.
	P. discoides, Foord & Crick.
	P. mixolobus, Phillips.
	Pronorites cyclolobus, Phillips.

Notes on each Species of Carboniferous Goniatites, with Distribution and Localities.

Genus **Brancoceras**.

Brancoceras enniskilleni, Foord. *Dibunophyllum* zone, D_2.

Derbyshire: Carsington.
Ireland: Blacklion, near Enniskillen.

Genus **Pericyclus**.

Pericyclus fasciculatus, M'Coy. ? *Dibunophyllum* zone, D_1.

Derbyshire: Kniveton.
Ireland: Little Island, co. Cork; Clane, co. Kildare.

Pericyclus Doohylensis, Foord & Crick. *Dibunophyllum* zone, D_1.

Derbyshire: Kniveton.
Ireland: Doohyle, near Rathkeale, co. Limerick.

Pericyclus divaricatus, Hind. Base of Pendleside Series to 3rd Grit.

Yorkshire: Cracoe Knolls, Flasby, Horsebridge Clough, near Hebden Bridge.

Lancashire: River Ribble at Dinckley Hall, 3rd Grit Shales, Eccup.

Cheshire: In the *G. spirale* beds, Congleton Edge.

Isle of Man: *P. becheri* beds, Poolvash.

Genus **Glyphioceras**.

Glyphioceras sphæricum, Phillips. Carboniferous Limestone, upper beds of Upper *Dibunophyllum* zone, D_2.

Lancashire: Black Hall.

Yorkshire: Keal Hill, Craven.

Derbyshire: Crowdecote, Castleton, Chrome Hill.

Devon: Fremington, Bonhay Road, Exeter.

Isle of Man: Poolvash.

Scotland: Upper Limestone Series: Gare. Lower Limestone Series: Corrieburn.

Ireland: Loughshinny, co. Dublin; Bantry, co. Cork.

Glyphioceras crenistria, Phillips. The upper beds of Upper *Dibunophyllum* zone, D_2.

This is an important zone fossil. It occasionally passes up into the *Prolecanites* zone just above it.

Lancashire: River Ribble at Dinckley Hall, Black Hall, and Cold Coats, near Chipping.

Yorkshire: Keal Hill, El Bolton, Rilstone. The Knotts, Bolland and Brockthornes, both 5 or 6 miles S.E. of Long Preston. Salterforth Railway Cutting.

Derbyshire: Castleton, Gluttondale, Chrome Hill.

Staffordshire: Wetton, Narrowdale.

Devonshire: Venn, Swimbridge, Bampton, and Bonhay Road, Exeter; Burlescombe.

Isle of Man: Poolvash.

Ireland: Foord quotes Queen's County and co. Fermanagh.

Glyphioceras fimbriatum, Foord & Crick.

The validity of this species is doubtful, and its locality is not recorded.

Glyphioceras striatum, Sowerby.

An important zone fossil which is common to the *G. crenistria* and *Prolecanites compressus* beds, and also in the *Posidonomya becheri* shales. Often crushed flat in shales, but easily recognized by its spiral ornament.

Lancashire: River Ribble Dinckley Hall, Cold Coats.

Yorkshire: El Bolton, Keal Hill, Flasby, Eastby. Beck half-mile N. of Ashnot inlier, Upper Hodder at Dalehead, between Hammerton Hall and Birch Hill.

Derbyshire: Chrome Hill.

Devonshire: Fremington.

Isle of Man: Poolvash.

North Wales: Teilia.

Ireland: Courtlough, Garristown, and Newton, co. Dublin; Drumscra, co. Tyrone.

Scotland: Upper Limestone Series: Gare. Lower Limestone Series: shale above Hosie Limestone, Campsie. Main Limestone: Carluke.

Glyphioceras obtusum, Phillips. The *G. crenistria* beds.

Not at all a common species.

Lancashire: Black Hall, near Chipping.

Ireland: Co. Cork: Blackrock, Little Island, and Middleton. Co. Waterford: Ballyduff. Co. Limerick: Ballynacarriga.

Glyphioceras phillipsi, Foord & Crick. Base of Pendleside Series to Millstone Grit.

Lancashire: River Ribble Dinckley Hall; Caton Green (Millstone Grit). Butler's Clough, Billington.

Yorkshire: Horsebridge Clough and Crimsworth Dean, Hebden Bridge (*G. reticulatum* zone); stream below Weets Head; stream north-west of Ashnot, Rilstone.

Staffordshire: Waterhouses (*G. reticulatum* beds).

Devonshire: Pinhoe Brickfield, Exeter.

North Wales: Holywell.

Glyphioceras micronotum, Phillips. Upper *Dibunophyllum* zone to Middle Coal-measures.

Lancashire: River Ribble Dinckley Hall; Rough Lee (Sabden Shales); River Hodder above the great falls.

Yorkshire: Rilstone and Lothersdale, 704 feet above Barnsley Coal, Brodsworth.

Staffordshire: Narrowdale, Wetton; above the Gin Mine Coal, North Staffs Coalfield.

Derbyshire: Castleton, Park and Chrome Hills, Thorpe Cloud.

Isle of Man: Poolvash.

Scotland: Upper Limestone Series: Orchard and Garngad Road. Lower Limestone Series: Shale over Hosie Limestone, Campsie, and Thornton.

Glyphioceras truncatum, Phillips. *Seminula* beds to Upper *Dibunophyllum*.

Lancashire: River Ribble Dinckley Hall, Black Hall, Cold Coats; ?Salt Hill, Clitheroe (*S.* beds).

Yorkshire: Keal Hill and El Bolton.

Derbyshire: Chrome Hill, Park Hill, Castleton, Thorpe Cloud, and Kniveton.

Staffordshire: Wetton, Narrowdale.

Isle of Man: Poolvash.

Scotland: Upper Limestone Series: Thornliebank.

Ireland: Drumscra, co. Tyrone; St. Donlaghs, co. Dublin; Clane, co. Kildare; Little Island, Tankardstown, Middleton, co. Cork; Lisnakeny, Nantenan, Ballyeahane, and Kilmacot, co. Limerick.

N.B.—The specimens quoted from Redesdale, Northumberland, in the Catalogue probably belong to a new species of *Pericyclus*, but

I have a specimen, a fragment of the body-chamber, which I think should be referred to *G. truncatum*.

Glyphioceras vesica, Phillips. From the *G. crenistria* zone to the *G. spirale* zone, D_2, and Pendleside Series.

Lancashire: Black Hall, River Ribble W. of Dinckley Hall.
Yorkshire: Crimsworth Dean.
Scotland: Upper Limestone Series: Bowertrapping, Gare, Robroyston, Auchenbeg. Lower Limestone Series: East Kilbride, Thornton.

Glyphioceras implicatum, Phillips. The *G. crenistria* zone, D_2.

I have not met with this species in any of the collections from the Hebden Bridge area that I have examined.

Lancashire: Black Hall, River Ribble at Dinckley Hall.
Derbyshire: Chrome Hall.
Isle of Man: Poolvash.
Scotland: Upper Limestone Series: Gare, Robroyston.

Glyphioceras mutabile, Phillips. From the *G. crenistria* zone to *G. spirale* zone.

Lancashire: River Ribble, W. of Dinckley Hall.
Yorkshire: Quarry 1 mile S. of Rilstone.
Derbyshire: Castleton, Storrs quarry, Bradbourne.
Staffordshire: Narrowdale.
Scotland: Upper Limestone Series: Gare, Robroyston.

Glyphioceras platylobum, Phillips. Pendleside Series to Millstone Grit.

Yorkshire: valley of the Nidd. Sabden Shales, Rough Lee; Gillbeck, S.E. of Lothersdale. Foord & Crick quote the species from Wetton, Staffordshire, and Todmorden.

Glyphioceras stenolobum, Phillips.

This must be a rare or doubtful species. It must be noted that the suture-lines figured by Phillips and by Foord & Crick are quite different. Neither Phillips's or their figures show that the shell has a wide peripheral sinus as stated in the text. Unfortunately the "type" has been lost, and the original locality, "Bolland," gives no information as to the horizon whence the type-specimen was obtained.

Glyphioceras nitidum, Phillips. *G. crenistria* beds to Millstone Grit.

Lancashire: River Ribble Dinckley Hall, Black Hall, near Chipping; Millstone Grit beds, stream N. of Haws House, 6 miles E. of Lancaster.

Glyphioceras bilingue, Salter.

An important zone fossil. At Pendle Hill it characterizes 300 feet of Black Shale below the Upper Pendle or Farey's Grit. It occurs in the Sabden Shales, W. of Sales Wheel, M.G.

Lancashire: Pendle Hill, Butlers Clough, Billington, and near Langho; River Ribble E. of Sales Wheel, Longridge Fell; streams N. of Chipping, Marsden Tunnel, Pule Hill.

Yorkshire: east bank of Winterburn Reservoir, stream half-mile N.E. of Thorlby, shales S. of El Bolton, stream half-mile S., and Clough, 1 mile S. of Ashnot; Hareshaw, S. of Lothersdale, below Weets Head and Eastby beck. Above Weston Grit, Clifton Bank, 1 mile N. of Otley. Millstone Grit Shales, Moreton Bank.

Derbyshire: River Dove, Glutton Bridge, Mam Tor, River Noe, Bradwell and stream W. of Bradbourne.

Cheshire: River Dane half-mile E. of railway viaduct; Wild Moor, Bank Hollow, E. of Macclesfield.

South Wales: Bishopton, near Swansea.

Ireland: Caher Lane and Rathcahill, near Abbeyfield, co. Limerick.

Glyphioceras reticulatum, Phillips. Pendleside Series to Middle Coal-measures.

An important species which when very young is strongly ribbed and has a wide and deep umbilicus and a deep groove on the periphery. As it grows the ornament becomes more delicately reticulate and in the old stage the shell may be almost smooth. Like *G. spirale* and *G. bilingue* the aperture is curved at the sides like a reversed S, and there is a deep sinus at the periphery. It is quite open to doubt whether the horizon at Hebden Bridge may not be Millstone Grit rather than Pendleside Series.

Lancashire: River Ribble W. of Dinckley Hall above the *G. spirale* beds, Pendle Hill above Hook Cliff; Sabden Shale, Rough Lee.

Yorkshire: Holden Clough, Bolland; High Green Wood, Crimsworth Dean, and Horsebridge Cough, Hebden Bridge; Millstone Grit Shales at Eccup and Wadsworth Moor, 705 feet above Barnsley. Coal, Brodsworth.

Derbyshire: River Noe and Mam Tor.

Staffordshire: River Dane, Dane Valley; Morridge. Shales below 3rd Grit, Shirley Brook, near Froghall.

Cheshire: River Dane, N. side of Dane Valley; Bosley Minn.

Devonshire: Doddiscombleigh; Pinhoe, near Exeter; Dunsford Road above Pocomb Bridge, bottom of Ashlake Road, Mincing Lake, Newton St. Cyres, under Slope Wood and Willhayes Copse; near Barnstaple.

South Wales, Pembrokeshire: Penally, near Tenby.

Scotland: Upper Limestone Series: Gare.

Ireland: Pendleside Series: Lisdoonvarna Doon, Mt. Phelim, and cliffs of Moher and Kilkee, co. Clare; Foynes Island and Rathcahill, co. Limerick; Mullaghtumy (Clogher), co. Tyrone; 5 miles N. of Maynooth, co. Meath; marine bands, Castlecomer Coalfield.

Glyphioceras davisi, Foord & Crick. *G. reticulatum* beds, Hebden Bridge to Sabden Shales.

Hitherto this fossil has only been found associated with *G. reticulatum*, and the study of a series of specimens in my collection has led me to suspect that it may be an old-age form of

that species. Haug, Mém. Soc. Géol. France, Pal., tom. vii, p. 90, has expressed the same view. Hind & Howe, on the strength of the locality quoted in the Cat. Foss. Ceph. Brit. Mus., p. iii, erroneously recorded this species as passing up into the Coal-measures (Q.J.G.S., vol. lvii, app. B).

Yorkshire: The *G. reticulatum* beds of Horsebridge Clough.

Lancashire: Sabden Shales of Rough Lee.

Staffordshire: River Dane, W. of salmon ladder.

Devonshire: Mincing Lane, near Exeter.

Ireland: Rathcahill and Foynes Island, co. Limerick; Puffing-hole, Kilkee, co. Clare; Coor Spa Well, near Ennis.

GLYPHIOCERAS EXCAVATUM, Phillips. *G. crenistria* zone.

Derbyshire: Castleton, Thorpe Cloud, Park Hill.

Staffordshire: Narrowdale.

Isle of Man: Poolvash.

Scotland: Upper Limestone Series: Orchard, Gare, Thornliebank. Lower Limestone Series: Thornton.

GLYPHIOCERAS BIDORSALE, Phillips.

A species of doubtful value. The late Mr. Crick referred a specimen in my collection from Horsebridge Clough to this species. Foord & Crick, op. supra cit., think it may be a form of *G. reticulatum*, and observe that the double median saddle on which Phillips founded the species does not exist in well-preserved examples.

GLYPHIOCERAS BEYRICHIANUM, de Koninck. Middle Pendleside Series to Millstone Grit.

This species has a most variable form. In the young stage the umbilicus, is wide and deep, inclusion small, the shell strongly marked with transverse ribs, the periphery broad and flattened, and like *G. reticulatum* has a central spiral sulcus.

In more mature shells the inclusion is more complete, the ribs more delicate, and the periphery more convex. Haug (op. supra cit., p. 92) describes and figures seven distinct varieties, all of which seem to come from Chokier. Similar varieties occur at Lisdoonvarna, co. Clare, and Rough Lee near Sabden.

My own observations lead me to suppose that the young stage of all the varieties are identical and occasionally persist, but the species was plastic and adopting new forms, or there may have been actually crossing going on between *G. reticulatum* and *G. beyrichianum*. Many specimens are very difficult to refer definitely to one or other of these species.

Gastrioceras circumplicatile, Foord, is probably a variety of the species. Haug points out that *G. diadema* is a synonym of *G. striolatum*, Phillips, and that as he adopts the latter as a distinct species the name *diadema* disappears and *G. beyrichianum*, de Kon., 1843, takes its place.

Lancashire: Sabden Shales, Rough Lee (Millstone Grit).

Yorkshire: Gillbeck, S.E. of Lothersdale (Millstone Grit); Horse-bridge Clough, Hebden Bridge.

Devonshire: Pinhoe Brickfield, near Exeter.
Derbyshire: Spoil-heaps, Edale Tunnel.
Cheshire: Silica quarry, Congleton Edge.
Denbighshire: Holywell Shales.
Pembrokeshire: Black limestones, seashore, Tenby.
Scotland: Upper Limestone Series: Orchard, Thornliebank. Middle Limestone Series: Black Band Ironstone, Dalry.
Ireland: Lisdoonvarna, co. Clare.

GLYPHIOCERAS STRIOLATUM, Phillips.

Foord & Crick have included this species as a synonym of *G. diadema*. Haug (Trans. Geol. Soc. France) distinguishes *G. striolatum* from *G. beyrichianum*, and I follow him.

It occurs in the *G. reticulatum* beds of High Green Wood and Horsebridge Clough, near Hebden Bridge.

Devonshire: Pinhoe, Barley, and Dunsford Road, ? Ashlake Road, Mincing Lake, and Perridge Tunnel.

Scotland: Upper Limestone Series: Gare, Robroystone, Orchard, Auchenbeg.

GLYPHIOCERAS CALYX, Phillips. Pendleside Series to Millstone Grit.

Yorkshire: Horsebridge and Crimsworth Dean; stream S.W. of Browsholm Hall; River Hodder; Sabden Shales, Gillbeck, S.W. of Lothersdale.

Ireland: Foynes Island.

GLYPHIOCERAS COMPLICATUM, de Koninck. Zone of *G. crenistria*.

Derbyshire: Castleton, Bradbourne.

This is the first note of the occurrence of this species in England.

GLYPHIOCERAS VESICULIFER, de Koninck. Zone of *G. crenistria*.

Yorkshire: El Bolton.
Lancashire: River Ribble, Dinckley Hall.
Isle of Man: Poolvash.

GLYPHIOCERAS PAUCILOBUM, Phillips.

Only one specimen known, possibly the type. Phillips recorded no locality.

GLYPHIOCERAS SPIRALE, Phillips.

An important Middle Pendleside zone fossil, occupying only a few feet of strata.

The species occurs at Clavier, Belgium, and in Ireland. Hitherto all British specimens have been found crushed. I have, however, been fortunate enough to extract a few uncrushed examples from nodules near Dinckley, one of which shows the suture-line to agree with the figure quoted by Foord & Crick after Roemer.

Lancashire: River Ribble, W. of Dinckley Hall; Pendle Hill, above Lower Pendle Grit; Sabden Shales, Rough Lee, a var. with fine ornament.

Yorkshire: Embsay Moor, black shales in beds N. of Eastby, beck three-quarters of a mile S. of Ashnot; Parkhead, Lothersdale.

Cheshire: Silica quarry, Congleton Edge.

Derbyshire: Lower beds of Mam Tor.

Devonshire: Waddon Barton; Bampton; Hele, east of Venn; Popehouse Close, Christow.

Ireland: Foynes Island, co. Limerick; Loughshinny; Summerhill, and near Trim, co. Meath; Killorglin, co. Kerry.

Probably *Goniatites granosus*, Portlock, from Tyrone, should be referred to this species.

Genus **Nomismoceras**, Hyatt, pars.

Nomismoceras spirorbis. *G. crenistria* to *G. striatum* zones.

Lancashire: Above the great falls, River Hodder; Ribble at Dinckley Hall; Black Hall.

Yorkshire: Rilstone, Crimsworth Dean.

Derbyshire: Storrs Quarry, Bradbourne.

Devonshire: Waddon Barton.

Ireland: Foynes Island, co. Limerick.

Nomismoceras rotiforme, Phillips. Generally confined to the *Posidonomya becheri* beds.

Lancashire: River Ribble Dinckley Hall. Pendleside Limestone: above great falls, River Hodder.

Yorkshire: River Hodder below Sandal Holm, and below bathing cots.

Staffordshire: Pepper Inn Wetton, and Narrowdale.

Isle of Man: Black marble quarry, Poolvash.

Ireland: Loughshinny.

Nomismoceras vittager, Phillips. Upper beds of D_2 to Pendleside Limestone.

Lancashire: Pendleside Limestone: above great falls, River Hodder.

Derbyshire: Storrs Quarry Bradbourne; Castleton.

Staffordshire: Narrowdale.

Nomismoceras ornatum, Foord & Crick.

Roof of Bullion Coal, Sholver.

Genus **Dimorphoceras**, Hyatt.

Dimorphoceras gilbertsoni, Phillips. Base of Pendleside Series to Middle Coal-measures.

A very widespread form.

Lancashire: River Ribble Dinckley Hall; Rough Lee (Sabden Shales).

Yorkshire: marine beds of Coal-measures and Pendleside Series: Crimsworth Dean and Horsebridge Clough; 705 feet above Barnsley Coal, Brodsworth.

Staffordshire: River Dane near Dane Bridge; marine bands of Coal-measures below Gin Mine Coal, 71 feet below 4th Coal, Cheadle; the coombes near Leek.

Derbyshire: Pendleside Series of Mam Tor.

Devonshire: *Gastrioceras* beds, Instow.

Ireland: Pendleside Series of Lisdoonvarna, Foynes Island; marine bands of Castlecomer Coal-measures.

Scotland: Lower Limestone Series: shale over Hosie Limestone, Thornton, Braidwood, and South Hill, Campsie.

Dimorphoceras discrepans, Brown. Pendleside Series to Coal-measures.

Yorkshire: Horsebridge Clough and Crimsworth Dean, Hebden Bridge; Sabden Shales, Rough Lee.

Lancashire: Lower Coal-measures, Sholver, near Oldham.

Ireland: Foynes Island and Lisdoonvarna.

Dimorphoceras looneyi, Phillips. Pendleside Series to Coal-measures.

Lancashire: River Ribble, Dinckley Hall.

Yorkshire: Crimsworth Dean and Horsebridge Clough.

Devonshire: Pinhoe, Exeter.

Ireland: Lisdoonvarna and Foynes Island (Pendleside Series).

Scotland: Lower Limestone Series: Boghead; Raesgill, Carluke; Thornton, over Hosie Limestone.

Genus **Gastrioceras**, Hyatt.

Gastrioceras carbonarium, von Buch. Upper Millstone Grit to Middle Coal-measures.

Lancashire, Yorkshire, Cheshire, and Staffordshire: above the Upper Mountain Mine or Bullion Coal.

Staffordshire: below the Gin Mine Coal, above Stinking Coal, Cheadle.

Devonshire: Instow and Clovelly.

South Wales: Rosser veins, Glan Rymney.

Gastrioceras listeri, Martin (?).

There is a great deal of doubt as to what was the original of Martin's figure, which resembles a Jurassic ammonoid. This, added to the fact that the species does not occur at the localities given, should, I think, cause us to utterly disregard Martin's figure, and to accept that drawn by J. de C. Sowerby, Min. Conch., vol. v, pl. D 1, fig. 1, right- and left-hand figs.

Martin says of his shell: "a common species. It is found in most of our limestone tracts, particularly near Eyam and Middleton." Sowerby, speaking of the occurrence of the shell, states: "This stratum may be traced from Middleton to near Leeds, and perhaps further."

The maximum of *G. listeri* is in the roof of the Bullion, Upper Mountain, or Hard-bed Coal, and it has not been found higher up than the Lower Coal-measures, but it certainly occurs below the 1st Grit or Rough Rock.

Spencer states that he found the species with *G. reticulatum* at the Hebden Bridge localities. "*G. Listeri* is very rarely found in the Millstone Grit rocks of this district (Halifax) . . . and it is only when we come to the Upper Millstone Grit shales that we find *G. Listeri* occurring in great numbers" (Trans. Manch. Geol. Soc., vol. xiii, p. 110).

Yorkshire and Lancashire: Everywhere over the Upper Mountain Mine or Bullion Coal.

Staffordshire: Below the Rough Rock, Millstone Grit, near Ipstones.
Devonshire: Instow.
Ireland: marine bands, Castlecomer Coalfield.

Gastrioceras coronatum, Foord & Crick. Lower Coal-measures.

Lancashire; above the Mountain Mine, Bacup.
Yorkshire: above the Mountain Mine, Shibden.

Genus **Prolecanites**, Mojsisovics.

Prolecanites compressus, J. Sowerby.

A most important zone form denoting the base of the Pendleside Series, and only occupying as a rule a few feet of beds, except on Pendle Hill, River Hodder, and Longridge Fell, where a great local expansion of the Pendleside Limestone occurs.

Lancashire: Warsaw End, Hook Cliff, Little Mearley Clough, Pendleton Clough, River Hodder below bathing cots, River Ribble at Dinckley Hall, at dip 2° in stream about one mile N. of Chipping.

Yorkshire: River Hodder below Sandal Holm, Salterforth railway cutting, Rilstone, Ingsbeck at base of Pendleside Limestone.

Cheshire: Old limestone quarry near Astbury, below Congleton Edge.

Devonshire: Coddon Hill, near Barnstaple.

Isle of Man: Scarlet Quarry.

Ireland: Co. Cork, Little Island and Black Rock, Middleton, Ballynabintra; Co. Galway, 4 miles east of Loughrea.

Prolecanites micolobus, Phillips.

Very rare. Phillips gave Bolland as the locality.

Prolecanites discoides, Foord & Crick. Carboniferous Limestone, D_2.

Yorkshire: El Bolton, near Cracoe.
Derbyshire: Park Hill and Brassington.

Prolecanites serpentinus, Phillips.

A very small shell. Base of Pendleside Series.

Lancashire: River Hodder, River Ribble at Dinckley Hall, Black Hall.

Pronorites, Mojsisovics.

Pronorites cyclolobus, Phillips.

Very rare. Carboniferous Limestone, D_2.

Yorkshire: El Bolton, probably; Grassington is quoted in Phillips's list of errata.

Derbyshire: Thorpe Cloud.

NEW GENUS.

Sagittoceras, Hind.

The genus is founded on a single specimen which consists of three-fourths of a complete individual. A large portion of the body-chamber is present, which on removal reveals the greater part of the penultimate whorl with the cameræ and suture-lines.

I obtained the specimen from Keal Hill, one of the well-known

Craven Knolls. It was in a block, on the south side of the hill, and from the accompanying fossils and nature of the rock came from the immediate vicinity. The beds on Keal Hill belong to the Upper *Dibunophyllum* horizon and are succeeded by the shales and black limestones of the Pendleside Series. *Glyphioceras crenistria*, *G. striatum*, and *G. truncatum* are common at the horizon at which the fossil was found.

I showed the specimen to the late Mr. G. C. Crick and left it with him for description, but his untimely death prevented him from publishing our views. He agreed with me that the suture-line denoted an ammonoid genus quite new to science.

Generic Characters.—Shell involute, discoidal, compressed with an acute periphery. Sides flattened. Umbilicus large and open. Cameræ numerous. Suture: an acute median saddle, external lobe broadly rounded, external saddle acutely linguiform, lateral lobe deep, rounded, linguiform, lateral saddle raised, acutely pointed, second lateral lobe broad and obtusely rounded.

Sagittoceras acutum, sp. nov. (Pl. XVI, Figs. 1, 1*a*, 1*b*.)

Specific Characters.—Shell discoidal, much compressed, with an acute periphery. Whorl sagittate in section, much higher than broad, inclusion about three-fourths; whorls 3 or 4. Umbilicus large and open, sides smooth, very gently convex, sloping towards the umbilicus, the edge of which is subangular and its margin convex.

Body-chamber occupies about one complete whorl. Cameræ many, about 20 to the whorl.

Suture as given under description of the genus above. Test thin, apparently smooth.

Dimensions. — Diameter, 83 mm. approximate; transversely, 30 mm. estimated.

Locality.—Upper *Dibunophyllum* zone of Keal Hill, Craven, Yorkshire.

Observations.—Dr. Foord[1] described under the name *Brancoceras enniskilleni* an acutely keeled Goniatite from the Carboniferous Limestone of Blacklion, near Enniskillen, in the Griffiths' Collection in the Science and Art Museum, Dublin, but the small umbilicus and general shape of the shell do not show any relation to that now under description, and Dr. Foord states that he saw the sutures and had "no doubt as to their being those of *Brancoceras*".

I obtained a fragment, two-thirds of a shell, which I refer to Foord's species, from the Carboniferous Limestone of Carsington, Derbyshire. The small umbilicus and greater thickness and less acutely angled periphery separate it at once from *Sagittoceras acutum*.

In external appearance *S. acutum* has a close resemblance to *Phacoceras oxystomum*, and may easily be mistaken for it if the suture-line is not seen.

The suture-line distinguishes the genus from all other Carboniferous forms by the rounding of the peripheral lobe, the acutely pointed external saddle, the presence of two lateral lobes, and a well-developed lateral saddle (Pl. XVI, Fig. 1*a*).

[1] *Carb. Ceph. Ireland*, p. 208, pl. xlvii, figs. 3*a*, *b*.

Pericyclus virgatus, de Koninck, has a lateral saddle and lateral lobe, but the shape of saddles and lobes are quite distinct from the genus under description. Pl. XVI, Fig. 1, shows the specimen after the body-chamber has been detached.

PERICYCLUS DIVARICATUM, Hind, 1905. (Pl. XVI, Figs. 2–6.)

Glyphioceras divaricatum, Hind, Proc. R. Irish Acad., vol. xxv, ser. B, No. 4, p. 144, pl. vi, fig. 6.

? *Pericyclus virgatus*, Foord & Crick, Cat. Foss. Ceph. Brit. Mus. Nat. Hist., pt. iii, p. 146.

Since the publication of this species much fresh material has accrued from many localities. The suture-line has also been seen and more perfect specimens examined. I now think it should be more correctly placed in the genus *Pericyclus*, Mojsisovics. I showed much of my material to the late Mr. Crick, and he expressed agreement with my conclusions. In many of the fossil lists I have published this species has been confused with *G. beyrichianum*. As the species was erected on fragmentary specimens I think it best to redescribe and refigure it in more detail. Its lowest known occurrence is in the *Posidonomya becheri* beds of the Pendleside Series, but it goes up as high as the 3rd Grit Shales of the Millstone Grit.

Specific Characters.—Shell discoidal, compressed, umbilicated, attaining a diameter of 70 mm. Greatest thickness at umbilical margin. Height of outer whorl, four-sevenths of the diameter of the shell. Whorls seven or eight, inclusion in the inner whorls almost *nil* but becoming in the outer three or four more and more complete. Umbilicus deep, open in the young, becoming relatively more narrow with the growth of the shell, its margin rounded, the under surface bevelled. Whorl elliptical in section, deeply impressed by the preceding one. Periphery narrow, convex, becoming obscurely keeled centrally in fully grown shells. Very feebly convex at the sides. Body-chamber occupies two-thirds of the last whorl. Suture-line as shown in Fig. 6.

Test ornamented with many flattened ribs which bifurcate about half-way between the umbilicus and the periphery. The grooves between the ribs, linear at first, become broader and equal, about half the measurement of the ribs in breadth. The ribs arch forward on the side, but on the periphery form a fairly deep sinus with concavity towards the younger part of the shell. A specimen from Cracoe Fells shows also spiral marking on the ribs.

Dimensions.—Greatest diameter, 70 mm.; width at umbilicus, 25 mm.

Localities.—Pendleside Series: silica quarry, Congleton Edge, Dinckley Hall River Ribble, Flasby, in watercourse between Butterhaw and Shelterton, and S. of Shelterton, Horsebridge Clough, near Hebden Bridge. *Posidonomya becheri* beds: Poolvash, Isle of Man. Millstone Grit Shales: Eccup, near Leeds. Ireland: Foynes and Foynes Island; Lisdoonvarna, in the Pendleside Series.

Observations.—The flat dichotomous ribs distinguish this species from all other described forms of the genus. *P. virgatus*, de Koninck, sp., has more rounded ribs, and these are not dichotomous.

Foord & Crick, Cat. op. supra cit., refer doubtfully some specimens, said to be from Halifax, to *P. virgatus*; they remark, "De Koninck says the ribs are not dichotomous, but they certainly are in these specimens up to a diameter of 16 mm." These shells most probably belong to the species under description. The species alters its habit with age. In the young the shell is much more globose and the ribs more transverse than in the adult, when the shell is more discoidal and compressed and the ribs sinuously curved on the side with a deep peripheral sinus.

The young stage may be confused with some forms of *G. beyrichianum*, but the umbilicus in the latter is much wider and inclusion less. The transverse ribs less close and more acute.

Pericyclus impressus, de Koninck, 1880. (Pl. XVI, Figs. 8–10, 12.)

Ann. Mus. Roy. d'hist. Nat. Belgique, tom. v, pt. ii, p. 118, pl. xlix, fig. 3.

Specific Characters.—Shell subglobose, involute, umbilicated. Whorls six, inclusion extensive, somewhat obtusely lunate in sections not very high. Umbilicus large and open in the young stages, becoming narrow with age; its border rounded, sides convex; the periphery convex.

Body-chamber occupies the last whorl. Cameræ four to a quarter of an inch. Suture as drawn below (Pl. XVI, Fig. 12*b*).

Test thin, with many simple transverse subangular ribs, the sulci between which have numerous fine spiral lines. On the periphery the ribs have only a suspicion of a hyponomic sinus.

Dimensions.—Fig. 9, Pl. XVI, measures, diameter 18 mm., transversely 10 mm.

Locality.—Millstone Grit Shales (Sabden Shales). Gill beck, near Cowling, Yorkshire.

Observations.—De Koninck's types were obtained from Vève, assise iii^{e}. The umbilicus at once distinguishes the species from others of the genus.

In the young the ribs are much less numerous, and the umbilicus wide, inclusion very small (Pl. XVI, Fig. 10).

All the specimens obtained were from one bullion in shale, a quarter of a mile above Stonehead Farm.

Pericyclus virgatus, de Koninck, 1880. (Pl. XVI, Fig. 7, 7*a*.)

Ann. Mus. d'hist. Nat. Belgique, tom. v, pt. ii, p. 118, pl. xlix, fig. 4.

I have two fragments of the body-chamber and one crushed example of this species from the Redesdale ironstone.

In his description de Koninck says, "Umbilie assez étroit à bords anguleux et infundibuliform," but his figure shows a moderately sized umbilicus with a convex border. The ribs are more numerous and flatter than in *P. funatus*, Sow., and less flat and less regularly dichotomous than in *P. divaricatus*, Hind. De Koninck's specimen was obtained at Visé.

Pericyclus redesdalensis, sp. nov. (Pl. XVI, Figs. 13, 13*a*, 13*b*.)

Specific Characters.—Shell moderately inflated, sides flattened. Evolute, umbilicus about $\frac{6}{16}$ in. in diameter, greatest thickness halfway between the periphery and umbilicus. Inclusion extensive.

Height of last whorl about half the diameter. Whorls ? 4, oval in section, broader than high, indented by preceding whorl. Umbilicus with somewhat raised and rounded margin and convex inner area, infundibuliform. Periphery very convex, marked off, in casts, from the lateral area by a spiral groove. Body-chamber occupies almost a complete whorl. Test unknown except on inner area of umbilicus, where there are many distinct, close ribs. The cast shows indications of numerous strong curved ribs, with a deep sinus backwards on the periphery. Suture-line as figured (Pl. XVI, Fig. 13*b*).

Dimensions.—Diameter, 43 mm.; transversely, 17 mm.

Locality.—Redesdale Ironstone, Northumberland.

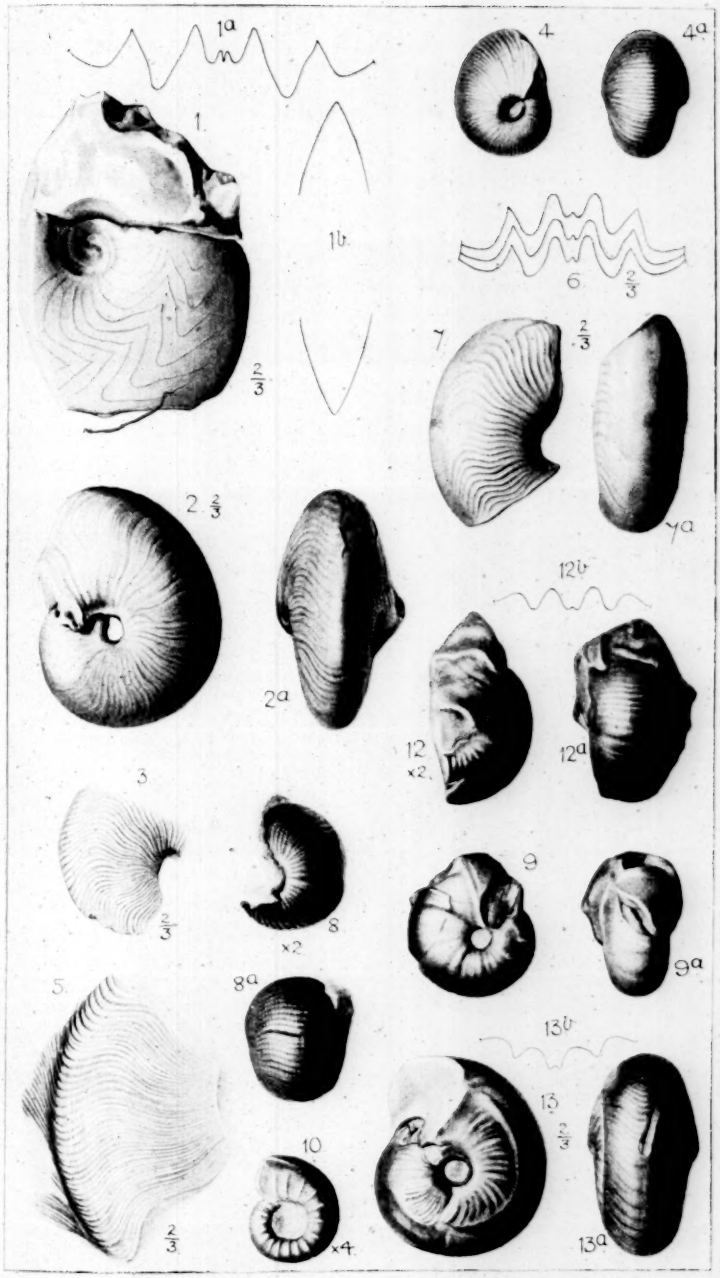
Observations.—Hitherto this shell has always been confused with *G. truncatum*, Phillips, from which it differs essentially in the shape of the periphery, which is less angular, the lateral area is less compressed, and possesses a spiral groove. The suture, too, has marked differences in the central saddle and peripheral lobe.

The late Mr. Crick pointed out to me that Fig. 13, Pl. XVI, shows an interesting condition of growth. The last septum is perfectly formed (*a*), a second septum was being formed (*b*), and a third septum is faintly indicated by a line forming the boundary of the muscle attachment. The sudden rise forward of this line indicated the commencement of the shell muscle. The spiral line on the left side of the shell is half an inch away from the margin of the umbilicus, while that on the right is much closer, only a quarter of an inch away. A younger specimen shows no spiral groove at all, so it probably is only an old-age character.

EXPLANATION OF PLATE XVI.

FIG.

1. *Sagittoceras acutum*, sp. nov. $\frac{2}{3}$ nat. size.
1*a*. Id. The suture-line. $\frac{2}{3}$ nat. size.
1*b*. Id. In profile. $\frac{2}{3}$ nat. size.
2. *Pericyclus divaricatum*, Hind. $\frac{2}{3}$ nat. size.
2*a*. Id. In profile. $\frac{2}{3}$ nat. size.
3. Id. Showing the ornament. $\frac{2}{3}$ nat. size.
4. Id. The young stage.
4*a*. Id. In profile.
5. Id. The ornament and orifice in adult. $\frac{2}{3}$ nat. size.
6. Id. The suture-line. $\frac{2}{3}$ nat. size.
7. *P. virgatus*, de Koninck. $\frac{2}{3}$ nat. size.
7*a*. Id. In profile. $\frac{2}{3}$ nat. size.
8. *P. impressus*. Showing the ornament. × 2.
8*a*. Id. In profile. × 2.
9. Id. Cast.
9*a*. Id. In profile.
10. Id. The young stage. × 4.
12. Id. Side view showing the ornament. × 2.
12*a*. Id. In profile. × 2.
12*b*. Id. The suture-line. × 2.
13. *P. redesdalensis*. Showing (*a*) last suture completely formed, (*b*) new suture commencing, (*c*) line forming the boundary of the muscular attachment. $\frac{2}{3}$ nat. size.
13*a*. Id. In profile.
13*b*. Id. The suture-line.



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BRITISH CARBONIFEROUS GONIATITES.

II.—The Recent Geological History of the Baltic and Scandinavia and its importance in the Post-Tertiary History of Western Europe.

By Sir Henry H. Howorth, K.C.I.E., F.R.S., F.S.A., F.G.S.

(*Concluded from the September Number, p. 409.*)

LET us now turn to the lessons presented by the Mollusca found in the raised beaches of Norway and Western Sweden.

Milne-Edwards was the first to discriminate the European molluscan fauna into geographical provinces. This he did in a paper in the Ann. Sci. Nat., 1838, p. 10. He separated our European seas into two provinces, which he called the Scandinavian and the Celtic. The latter included the English Channel, the coast-lands from Ireland to Gibraltar, and those of the Mediterranean.

S. P. Woodward, in his *Manual of the Mollusca* (1851–6), pt. iii, ch. ii, "Geographical Distribution," pp. 357–61, 1856, makes the Faeroe and Shetland Islands and the coast of Norway from the North Cape to the Naze a part of his "*Boreal* province" (ii, p. 357) and leaves the British Islands, Denmark, Southern Sweden, and the Baltic in Milne-Edwards' *Celtic* province (iii, p. 359).[1]

The coasts southwards from the English Channel to the Canary Islands, and those of the Mediterranean, S. P. Woodward named the *Lusitanian* province (iv). These names have maintained their place. To these provinces has been added an Arctic one, which was apparently first suggested by S. Löven in 1896. The names were accepted by the elder Sars, who, however, limited them; thus the Arctic province with him comprised only the circumpolar area bounded by the Arctic Circle. The Boreal region he extended from the Arctic Circle to Cape Finisterre, in about lat. 48°. South of this and including the west coast of France, Spain, Portugal, the Mediterranean, the Azores, and the north-west coast of Africa to the Canaries he included in his Lusitanian region. The younger Sars in his fine work on the Arctic fauna of Norway altered the boundary of his father's Arctic province so as to include the Lofoten Islands. His new boundary passed through the North Cape. He justified the diversion of the line in the latter place because of the Gulf Stream, which causes a great difference between the east and west coasts of that promontory, thus creating a similar frontier to that caused by Cape Cod in North America.

These divisions (like all classifications of natural objects) are, of course, very largely arbitrary, for the different classes naturally overlap. Wherever we put down our dredge in the European area, or wherever we sort the shells from a raised beach, we shall meet with the fact that some of the molluscs have a very elastic and adaptable constitution. They can live and thrive in many varied conditions if they can only get food, and we always have to be careful in making general inductions from a single species or small

[1] Of 289 Scandinavian shells catalogued by Dr. Löven, 217, or 75 per cent, are common to Britain.

group of species, especially if we are tied down to some theory which has to be supported at all costs and which distorts our vision when we look the facts in the face. It is only too easy to select a number of shells which seem to thrive as well in the Scandinavian or British seas as in the Arctic Ocean, to dub them Arctic and then to apply the term Glacial to a deposit. Again, even the best of the older conchologists have at times failed to discriminate small differences and varieties which may entirely sophisticate the conclusion. I will quote a good example which happens to be very familiar to me because I wrote a monograph on the shell, viz. *Mya arenaria*, which was published in the Proceedings of the Zoological Society.[1] There can be no doubt from the evidence that *M. arenaria* is a new addition to the fauna of the North Sea and its outliers. There is no evidence that it existed there before the beginning of the seventeenth century. It was first described by Lister in 1678.

Gwyn Jeffreys, who did not know this, in his account of the Mollusca of the Uddevalla raised shell-bed, not only claimed to have found this species of *Mya* there, but made a somewhat characteristic deduction in regard to it. He described it as an Arctic shell, and says of it, "The occurrence of this circumpolar shell-fish so near the Tropic of Cancer probably indicates the most southern limit in space of the Glacial epoch" (*British Conchology*, iii, pp. 65–6).

Jensen, a much more critical person than Gwyn Jeffreys, has, in fact, proved most completely that *M. arenaria* is not an Arctic shell at all and does not exist in the Arctic regions. Gwyn Jeffreys had mistaken another and very different species with an entirely different habitat for it, namely *M. truncata*, var. *ovale*, which is a very high Arctic shell and has been found in Iceland, Greenland, Spitzbergen, Nova Scotia, and the Kara Sea. The mistake of Gwyn Jeffreys was a particularly unfortunate one, because it was copied into several geological works and made the basis of several most illegitimate deductions. (For details of the whole discussion I must refer to my paper in the Proceedings of the Zoological Society, 1909, pp. 745–67).

On several other occasions, as it seems to me, Gwyn Jeffreys used the word "Arctic" as applied to the habitat of certain shells from the raised beaches in a very arbitrary way.

It does not follow, again, that when truly Arctic shells are found in more southern waters they should be always dubbed as Arctic. Before so naming them we must be careful to consider measurements and other differentiæ. Many Arctic shells occur in our Northern seas which only attain their normal and typical size in very high latitudes and become dwarfed in size and otherwise modified further south. There are others which ought not to be called Arctic at all, because they thrive just as well in temperate regions as they do in Arctic ones, having the adaptability of Scotchmen. So that considerable care and judgment are required in order to justify the application of the term "Arctic" to groups of Northern shells.

[1] "Some living Shells, their recent Biology and the light they throw on the latest Physical Changes in the Earth [*Mya arenaria*]," by Sir H. H. Howorth (Proc. Zool. Soc., 1909, pp. 745–67).

In Brögger's admirable monograph on the molluscs of the raised beaches in the Christiania Fjord he has compared the living fauna of this great Norwegian bight or inlet with that in *the later* raised beaches of Norway, and has shown that a certain number of the molluscs now found living in Norwegian waters are not found in these beaches at all, and he very naturally infers from this that they have invaded these waters since the latest beaches were deposited, a large proportion of them having probably come as a direct or indirect consequence of human effort.

It is interesting to analyse these immigrants. Five of them which seem to thrive and flourish in the temperate waters of the Christiania Fjord belong to the highest latitudes. They are *Acmæa testudinalis*, *Lophyrus albus*, *Scalaria Groenlandica*, *Cerithiopsis costulata*,[1] and *Nucula delphinodonta*. The notable thing about these five high Arctic shells is that not only are they not found in either of the two sets of raised beaches in the Christiania Fjord, they are also not found on the Arctic shores of Northern Asia from the Kara Sea eastwards, but occur abundantly in the Arctic lands of the New World from Behrings Straits to Greenland, and Brögger has no hesitation in treating them as Nearctic shells which have migrated in late historical times to Europe, having, not improbably, been transported by whalers and seal-fishers. The notable thing to remember about them is that they seem to thrive under such new conditions.

We will now turn to a number of Boreal species which have, probably, found their way into the Norwegian waters in recent years, notably:—

Mya arenaria (of which we have spoken above), *Tellina pusilla*, *Macoma tenuis*, *Psammobia tellinella*, *Rupicola distorta*, *Necera rostrata*, and *Rissostomia octona*, all recent introductions from the West.

Lastly the Lusitanian species, which have immigrated since the latest raised beds were laid down, viz.:—

Lima hians, *Modiolaria marmorata*, *Nucula nitida*, *Sphænia Binghami*, *Teredo navalis*, *Trochus zizyphinus*, *Hydrobia ventrosa*, *Onoba costata*, *Cingula semistriata*, *Turbonilla scalaris*, *Stilifer Turtoni*, *Mangelia attenuata*, *M. striolata*, *Scalaria Turtoni*, *Aplysia punctata*.

It is not possible to know how these vagrants found their way into Scandinavian waters during a period when the climate, as we shall see presently, has been only slightly changed, nor would a change of climate avail as a reason, for the newcomers belong to different marine climatic regions. In regard to the Lusitanian migrants I have a theory which I think interesting, but must postpone to another paper.

From these recent comers we will turn to the shells which are found in the *later* raised beaches, but no longer live in the neighbouring sea. The total number of shells from these beaches is 255. Forty of these are Arctic, 103 Boreal, and 112 Lusitanic. Of these 210 are now living, leaving 45 species represented in the beaches

[1] This species, which does not occur in the beaches of the Christiania Fjord, has been found in those at Uddevalla and in Britain.

but not now living in this region, 14 of which are Arctic, 9 Boreal, and 22 Lusitanic.

The 14 Arctic forms are:—

Terebratella Spitzbergensis, *Pecten islandicus*, *Portlandia lenticula* (?), *Tridonta borealis*, *Panopæa Norvegica*, *Molleria costulata*, *Margarita Groenlandia*, *M. cineraria*, *Morvillia undata* (?), *Marsenina micromphala*, *Trichotropis borealis*, *Littorina palliata* (?), *Sipho togatus* (?), and *Utriusculus pertenuis*.

The 9 Boreal species are:—

Gwynnia capsula (?), *Montacuta Vöringii*, *Solen ensis* (?), *Cadulus propinquus*, *Lamellaria latens*, *Auriculina diaphana*, *Sipho gracilis* (?), *Neptunea antiqua* (?), and *Utriculus obtusus*.

The 22 Lusitanic species are:—

Arca tetragona, *Cardium tuberculatum*, *Tapes decussatus*, *Lepton squamosum*, *Scrobicularia piperata*, *Lasæa rubra*, *Tellina crassa*, *Macoma fabula*, *Psammobia vespertina*, *Solecurtus antiquitatus*, *Pholas candida*, *Cingula soluta*, *Onoba vitrea*, *Alvania reticulata*, *Aclis ascaris*, *A. unica*, *Turbinella lactea*, *Odostomia albella*, *Culinella nitidissima*, *Clathurella purpurea*, *Mangelia nebula*, *Philine pruinosa*.

(Brögger, op. cit., pp. 577, 578.)

Some species like *Isocardia cor*, existing both in the beaches and living, were formerly very common in the Christiania Fjord, but are now *very* rare; others are decidedly rarer now than they were, such as *Pecten varius*, *P. septemradiatus*, *P. opercularis*, and the oyster.

In one matter I would take exception to Brögger's classification of the later beaches, which he groups together under the name post-Glacial beds. Having named the greater number of them *Tapes* beds from the presence in them of that very characteristic shell, he proceeds to treat others, which agree with the *Tapes* beds virtually in all their other contents but in which the *Tapes* have not been found, as belonging to a different horizon. This seems to me to introduce a quite unnecessary complication into the problem, unjustified by the evidence. There are only a limited number of molluscs which are sufficiently elastic to live under very different conditions of food and bottom, and the occasional absence of a particular shell is often merely due to peculiar local conditions.

Every shell-collector knows as an elementary fact that when we pass from clay to mud or sand or gravel or rocks, we at once lose certain of the species which are perfectly contemporaneous and which are now living in different parts of the coast of the same sea. The complete absence of the *Tapes* and the oyster from the modern Cattegat, although they were abundant there before the Baltic breach, shows that they were not capable of tolerating certain changed conditions like others of their companions could, and we must in such cases take the general facies of the contents of the beds, and not the presence or absence of a particular shell, as justifying us in creating a new horizon.

In regard to the dying out of the forms it is not easy to give an entirely satisfactory explanation, for they belong to all three of the geographical provinces into which the mollusca have been divided by Brögger. It is possible that the reduction in the salinity of the

water due to the outflowing of so much fresh water from the Baltic, which certainly destroyed some, may have had a wider influence than we know. Another cause to which we will turn presently is the great shallowing of the water in certain cases, and a third a possible change of the temperature of the water affecting the supply of food. What is important to remember is that the mollusca represented by the so-called post-Glacial beds belong essentially to that of the *Tapes* beds of the Cattegat beaches, and that although *Tapes* is extinct in the Christiania Fjord, two species of the genus are no longer found there, but are still found living in the North Sea and on the Western Norwegian coast. Dr. Brögger, in fact, as I have said, calls the greater number of the beds occurring in the Christiania Fjord, which he classes as post-Glacial, the *Tapes* beds.

I would venture very deferentially, therefore, to differ from him in allocating anything more than a quite relative value to the presence or absence of any particular shell from a bed as a test of its age or homotaxis. I would treat them as the result merely of different local surroundings and as being entirely local divisions, and in this case I would name them all *Tapes* beds, and use that name in the sense in which Dr. Brögger uses the name post-Glacial beds.

Turning to these *later* or so-called post-Glacial beaches in the Christiania Sound, I will give a list of some of their heights above sea-level as reported by Sars (op. cit., p. 3):—

On the east side of that Gulf.	Heights above sea-level. Feet.
Skullerud in Höland	437
Nordby on the Ogdered Lake	516
Sververud (Oppegaard) near Eidsberg	540
Killebo and Damholt in Rakkestad	440, 475
Kolbjörnsvik in Aremark	400, 410, 455
Skjaedal, Hellesaa	476–454
Björndal in Aremark	385–375
Sandbol-Skjaeldal	350
Moen in Aremark	457

To each of these numbers Sars would add 90 feet in order to ascertain the actual depth at which the molluscs live.

Let us now turn to the high Arctic beds, which have a good deal more importance and interest for us than the later or post-Glacial ones.

I have stated that in the Christiania Fjord and in the northern part of the Cattegat, in addition to the *Tapes* beds which occur at different levels, we have another series unmistakably contrasted with them, since they only contain shells belonging to an extreme Arctic type, while on the other hand the two sets of beds have none of their shells in common, so that in dealing with them we get rid of all the difficulties of overlapping. These beds have been called from their most characteristic shell *Yoldia* clays. They present some critical problems in which I find myself in sharp difference with the Northern writers.

The fauna of these beds comprises the following twenty-six species of molluscs and a number of varieties.

SPECIES AND VARIETIES OF SHELLS CHARACTERISTIC OF THE YOLDIA CLAYS.

1. *Macoma (Tellina) calcarea*, var. *maxima*.
2. *Saxicava arctica*, var. *Uddevallensis*.
3. *Pecten islandicus*.
4. *Leda pernula*, var. *costigera*.
5. *Nucula minuta*.
6. *N. tenuis*, var. *expansa*.
7. *Lyonsia arenosa*.
8. *Lepeta cocca*, var. *major*.
9. *Natica affinis*, var. *clausa*.
10. *Lunatia Groenlandica*.
11. *Astarte undata*.
12. *Buccinum terra-novæ*, var. *grandis* and var. *a*.
13. *B. hydrophatium*, var. *elata*, var. *fusco-rufescens*, var. *textulata*.
14. *Neptunea despecta*, var. *carinata*.
15. *N. denselirata*, n.sp.
16. *Sipho togatus*, var. *Pfaffii*, var. *sinuosa*, var. *vallensis*.
17. *S. brevispira*.
18. *S. islandicus*.
19. *S. Verkrützeni*, var. *plicifera*.
20. *Trophon truncatus*, var. *major*.
21. *Cylichna Reinhardti*.
22. *Modiolaria nigra*.
23. *Portlandia arctica* = *Yoldia arctica*, var. *siliqua*, var. *portlandica*, var. *inflata*, var.
24. *Yoldia hyperborea*.
25. *Admete viridula*.
26. *Bela nobilis*, var. *rugulata*.

(Brögger, op. cit., pp. 31, 32.)

Of these species and their varieties 26 have been found at Glommen between Sarpsborg and Frederikstad, 11 at Sandefjord, 8 at Tönsberg, and 9 at Moss.

From the *Yoldia* clay at the last named of these places Brögger also enumerates a number of Foraminifera, and among them he characterizes *Polystomella arctica* as being a high Arctic species (op. cit., 33 and 670).

I will now give the living habitat of some of the above shells:—

Macoma calcarea. The coasts of North Siberia and North America, Greenland, and Spitzbergen.
Saxicava arctica. The Kara Sea and North Siberian coast and West and North Greenland.
Pecten islandicus. Greenland and Finmark.
Leda pernula, var. *costigera*. North Siberian coast and Greenland.
Nucula tenuis. North Siberia coast, Spitzbergen, Melville Bay, and Greenland.
Lyonsia arenosa. Nova Zembla and West Greenland.
Lepeta cocca. Greenland and Grinnell Land.
Natica affinis. The Kara Sea and generally circumpolar.
Lunatia Groenlandica. North coast of Asia, Greenland, and generally circumpolar.
Astarte undata. Kara Sea, north coast of Asia, Spitzbergen, and Greenland.
Buccinum terra-novæ. Nova Zembla, North Siberian coast, the islands of the St. Lawrence, and Greenland.
B. hydrophanum. East Greenland and Spitzbergen.
Neptunea despecta. Finmark, Nova Zembla, and north coast of Asia.
Sipho togatus. Kara Sea, north coast of Asia, and Spitzbergen.
S. islandicus. Nova Zembla, north coast of Siberia, Gulf of St. Lawrence, Spitzbergen, and Greenland.
Trophon truncatus. North coast of Siberia and Greenland.
Cylichna Reinhardti. Nova Zembla and north coast of Asia.
Modiolaria arctica. Finmark.
Portlandia arctica. Nova Zembla, the Yenissei, Franz Joseph Land, and Greenland.
Yoldia hyperborea. Greenland, Spitzbergen, and Finmark.

In a few instances we find that these shells have occasionally wandered somewhat south of the Arctic Circle, but generally the more southern specimens are dwarfed and distorted.

These deposits of Arctic shells have been named after a very characteristic Arctic mollusc formerly known as *Yoldia arctica* and now as *Portlandia arctica*.

It is only lately that the widespread occurrence of the *Yoldia* in the raised beds of Scandinavia has been ascertained. Hisinger was the first to find it in Scandinavia at Aker in West Gothland in 1837, while Torell found it in a submarine clay at Varberg in 1848. It was found on the shores of the Mälar Sea in 1852. Sars found it in Southern Norway in 1861 and described it from there in 1863 and 1865. Presently Esmark found it on the west side of the Bight at Sandefjord and Ranviken. It was Brögger, however, who added so greatly to the number of its known sites, thirty of which are now known. Of these he enumerates twenty-four from the Christiania Fjord (op. cit., 669–70). He gives full details with a map on pp. 8–54 to the same work.

At Wenersborg A. Lindstrom found the shell and other shells, while at Gothenburg Torell met with it a few metres above the sea; V. Munthe found the same shell at Kollekän and on the island of Tjörn in Bohuslän, in the former case at a height of 5 to 7 feet and in the latter at 10 feet above the sea-level. With it occurred *Peeten islandicus*, *Portlandia arctica*, *Macoma* (*Tellina*) *calcarea*, and *Saxicava rugosa*.

Crossing over the Cattegat we have a similar set of beds which have been described by Johnstrup, V. Madson, and A. Jessen from Vendsyssel, that strip of North Jutland forming a long narrow peninsula separated from the mainland by the Limfjord. The species found in the *Yoldia* beds of this district consist of *Modiolaria discors*, *Nucula tenuis*, *Leda pernula*, *Portlandia arctica*, *P. lenticula*, *Axinopsis orbiculata*, *Axinus flexuosus*, *Macoma calcarea*, *M. mosota*, *M. crassula*, *Lyonsia arenosa*, *Mya truncata*, *Saxicava pholadis*, *Natica* sp., *Bela nobilis*, *Trophon clathratus*, *Buccinum Groenlandicum*, *Neptunea despecta*, *Cylichna Reinhardti*, *Utriculus pertenuis*. On this list Brögger comments thus: The commonest species are *Saxicava pholadis*, *Portlandia arctica*, *Modiolaria discors*, *Macoma calcarea*, *M. crassula*, and *Cylichna Reinhardti*.

All these species, with the exception of *Axinopsis orbiculata*, are living in the Kara Sea and also in the Greenland seas. The fauna from Vendsyssel, he continues, has the same Arctic character as that of the *Yoldia* beds of the Christiania Fjord, although not quite the same species. Jessen has found the *Yoldia* clay in this district as high as 33 metres.

In the island of Laesö in the Cattegat, according to Jessen, the same high Arctic species have been found at an elevation of 3 metres and more. From Halland and Dalsland in Western Sweden the *Yoldia* beds have long been known. Hisinger was the first to find *Yoldia* at Akersvass and Trollhätten, and with it a number of other molluscs from 12 to 15 metres or 40 to 50 feet above the sea-level.

In Western Norway Torell found it in 1860 at Lademoen and

Baklandet in Trondhjem, and his discovery was recorded by Sars in 1865. Here it was 12½ metres above the sea. Kjerulf reported similar finds at Kläbu, Selbu, and Nidelven in the same province, apparently up to 130 or 150 metres (ibid., 124–9). In Nodland and at Nidelven it was found by Rekstad.

I have described the localities where the *Yoldia* fauna has occurred in considerable detail because of the important place which it has filled in geological polemics, and because for a long time the deductions based upon it had to be supported by very limited examples. It is now obvious that the fauna was widely spread over the area once occupied by the Christiania Fjord, the northern Cattegat, and the Eastern Gulf, which included the Great Lakes of Sweden.

Let us now turn to the lesson which these beds have to teach us and which I claim have been completely misunderstood. There is no question about *Yoldia* and its companions being very high Arctic shells, nor is there any ambiguity in interpreting the evidence caused by the mixture of shells occurring in other beds or living under more temperate conditions. It is perfectly plain that at the horizon where these shells lived the temperature must have been very low. This is indisputable. There are other facts, however, which preclude the explanation of their surroundings offered by Brögger, and which have led him and many others, including the late Professor James Geikie, to postulate that when they were living Scandinavia must have been under glacial conditions. I especially propose to deal with Brögger's arguments.

First, then, about the relative position of the *Yoldia* beds to the later or *Tapes* beds, and especially in the Christiania Fjord where they occur together. The *Yoldia* beds in this district do not occur higher than from 40 to 50 metres or a little more above the sea-level, while the later beds in which the molluscs are virtually the same as those now living in the adjoining sea have been found by Mr. Öyen at Grefsen and Arvold, near Christiania, as high as 203 to 208 metres (Brögger, op. cit., 693). I have given a series of other heights attained by them in this district in an earlier page. The *Yoldia* clay, says Brögger, occurs at the height of 40 to 60 metres in some places. At lower levels, he says, they occur at Nevlung, Laven, Sandefjord, Tönsberg, Asgards Strand, Horlten Moss, and Råde, by the Glommen, etc., on the present shore-line and only a few metres above it. That is to say, in this district the *Tapes* beds lie far above the *Yoldia* beds. Elsewhere the two sets of beds occupy the same relative position towards each other wherever they occur together in other parts of Scandinavia. It seems to me inevitable that this involves the conclusion that the *Tapes* beds emerged from the sea before the *Yoldia* beds. That is the conclusion Brögger has himself drawn in the similar case of the *Ancylus* beds and the *Litorina* beds of Sweden, and it cannot be evaded.

It is also plain that the molluscs of the upper or *Tapes* beds, which are rich in the number of species, are, with very slight and negligible exceptions, all of the same forms as those now living in the adjoining seas, while none of those in the *Yoldia* beds are now

living there. Not only so, but it is plain that whenever and wherever they lived they were surrounded by Arctic conditions. This is indisputable. What I dispute is that they in any way testify to a Glacial period. If they did so, that Glacial age must have intervened between the period when the *Tapes* beds were uplifted and the present conditions of climate in the Scandinavian seas, which biologically are duplicates of each other. This would mean, first, that the postulated Glacial period was intercalated between two periods marked by the same temperate marine fauna. In other words, the fauna of the *Tapes* beds must have been entirely exterminated by the extreme Arctic climate of the *Yoldia* period, and then the latter must in turn have been similarly exterminated and replaced by the older inhabitants, after which a return to precisely the same conditions again took place.

Apart from all other considerations, the proposed theory involves not merely a gradual change of climate, but a sudden and drastic one, or else there would be some evidence of a gradual transition of fauna, whereas there is none, but a complete and drastic change of the whole fauna. Secondly, there is the puzzle of explaining whither the remnants that escaped the extermination fled, and whence they could return to their old homes in better times.

Surely such a position is preposterous and unbelievable unless supported by overwhelming evidence. As a matter of fact, Dr. Brögger produces no evidence at all, but only a quite fallacious deductive argument. He says quite rightly that in the high Arctic sea where the *Yoldia* and its companions are found, they mostly live at a depth of from 10 to 30 metres, a number of them, he adds, living at greater depths (op. cit., 681). He then goes on to argue that the same species of molluscs when it lived in the Scandinavian seas must have lived at about the same depths, notwithstanding the great difference in latitude. To justify the immense postulate he relies on the still more wilful one of a Glacial nightmare as his *deus ex machina*, and entirely ignores the two fundamental difficulties I have just pointed out.

It seems to me that a very much more simple explanation of the phenomena we are discussing is available which needs no fantastic postulates to support, but only an accurate induction from the known facts. I would urge in answer to Dr. Brögger that what the *Yoldia* and its companions require for their existence is not a uniform depth of water in all latitudes where it lives, but a fairly uniform *temperature* in the water. That temperature *exists now* not only in the Arctic Circle but in the depths of the Atlantic and of the North Sea, and needs no Glacial nightmare to create it in those latitudes. It has not truly been proved to do so by a great many deep-sea soundings, and it is an inevitable corollary from the interchange of warm and cold water between the temperature of Arctic regions as a result of natural laws of ocean circulation.

We all know the elementary example which has been so often quoted, namely, the existence of living northern molluscs, not only in the boreal latitudes of Christiania, but in the southern one of the Mediterranean. These molluscs do not occur there at the same depth

that they do in the more northern latitude regions, but very much deeper. They occur in its abysmal depths, and we know quite certainly that they occur there in very cold water. We also know that the cold water in question is brought in by a deep current of cold water from the Atlantic and has its complement in an outgoing upper current which flows outwards. Not only so, we have an example of the concurrent and contemporaneous effects of the presence of a warm and an Arctic current side by side in Finmark and the Lofoten Islands. In the former case the two zones of life are separated by the North Cape, and in the latter by the islands just named. In each case, within a few miles of each other, we have the *Yoldia* fauna and the *Tapes* fauna living quite happily at the very same time, the one supplied by an Arctic current and the other by the Gulf Stream. Not only so, but off the north-west of the Lofoten Islands, the *Yoldia* occurs living, not as Brögger demands, at a depth of 10 to 30 fathoms, but of 60 to 100 fathoms, as we should expect with the change in the latitude. We naturally conclude that if these conditions, but on a greater scale, were repeated in the latitude of the Christiania Fjord by a sufficient depression of the sea bottom, the Arctic water would necessarily find its way thither and the *Yoldia* and their friends would thrive there, while at a higher level quite close by, there would be living precisely the same fauna as lives there at this moment. This is what is actually occurring on some of the Norwegian fjords, where the great depth of water at their lower end has induced a contrasted fauna between their upper and lower reaches.

Now it is quite certain that the molluscs in the raised *Tapes* beds of the Trondhjem and Christiania Fjords were living several hundred feet below the present raised beach levels, or rather at a greater depth still, for we must add probably 90 feet to the level of the latter in order to secure them a sufficient submergence. Inasmuch as the difference in the present level between the *Yoldia* beaches and the *Tapes* beaches in the Christiania Fjord is very considerable, at least 400 feet, it follows that the former must have been submerged to a much greater depth than the latter, and in fact to a depth approximating to 800 or 1,000 feet. In that case the necessary conditions for the life of *Yoldia* must have existed there in the same way that they exist in the North Lofoten waters now, only at a greater depth. This seems to me to be an exceedingly simple explanation, and it is conclusive for those who do not believe in transcendental causes. It further dispenses with all the see-saw and rocking-horse machinery of earth movements against which Suess protests so strongly, which are incompatible with these movements, having been caused by lateral thrusts, as now generally held, and which the glacial theory requires to explain the facts. This is not all, we can produce direct evidence of a very interesting kind that the explanation here maintained is the true one.

It is at all events a very remarkable fact that while the *Yoldia* has become extinct in the Norwegian seas except in the north-west corner of the Lofoten archipelago and perhaps the extreme north of Finmark, the whole sea bottom along the coast of Norway is

covered with its dead shells, and it would seem almost certain that this extinction of the shell was due to some uplift having interfered with the Arctic water reaching that latitude in sufficient quantity. Apart from this, the depth at which these dead shells are found (in an area where the latest movements have been those of elevation) shows that the *Yoldia* when living in Norway lived at a very much greater depth than that suggested by Dr. Brögger as a necessity of its life.

There is another fact which is equally or still more impressive in this behalf. We owe this notable piece of evidence to the researches of Sars. He describes a famous reef near Dröbak, south of Christiania, with an area of some 100 kilometres. This is in places submerged to the depth of several fathoms, and in others it rises above the sea at Barholmen, Kaholmen, etc., to a height of 30 metres above the water-level. This reef is covered with a great deposit of the dead coral *Lophohelia* (*Oculina*) *prolifera*, which is bush-shaped and forms growths two feet in diameter and is accumulated in vast masses. It cannot have been washed thither by the tide or a stream, for it is firmly attached to the solid rock just as it grew. Although it only occurs dead here, it is found living at vast depths in the deeper fjords. Sars says at 150 to 200 fathoms, i.e. 900 to 1,200 feet more or less. A. M. Norman found it in Bokkenfjord and Korsfjord at a depth of 80 fathoms. Sars and Brögger both claim for its habitat a very great depth. With it occur the very interesting shell *Lima excavata*, together with *Pecten vitreus*, *Arca nodulosa*, *Cardium minimum*, *Waldheimia cranium*, *Terebratella Spitzbergensis*, and *T. caput-serpentis*.

This is a clear proof that when the coral was living the depth of the Christiania Fjord at Dröbak must have been quite great enough to admit the Arctic current into that gulf, which then extended as we have seen in a great inlet as far as the Mälar Sea and including the Cattegat, the peninsula of Vendsyssel, the great lakes of Wettern and Wenern, of Mjösen and the Mälar Sea, in whose depths we have a number of still living relics of the same cold conditions once prevailing there.

In conclusion, I wish, among other things, to emphasize in these pages that the molluscan contents of the raised beaches completely confirm the geological evidence of the very recent, continuous, and cataclysmic uprise of Scandinavia and of the sea bottom round its coasts, thus affording a complete parallel to the similar rise of the other great peninsula of Greenland which I have described elsewhere. One or two consequent results I have no space at present to enlarge upon and can merely mention. One is that the breaking of the Baltic breach created a complete gap in the history of the fauna and flora of Scandinavia, which from that date to our own can have altered very slightly and adventitiously; and secondly that the rise of such a mass of land in these high latitudes must have considerably lowered the temperature and affected the internal distribution of the plant and animal life in both of which respects the evidence of biology completely concurs. I hope to enlarge on these issues and to apply directly the arguments here used to Britain on some other occasion.

III.—Notes on some Fossil Arthropods from the Carboniferous Rocks of Cape Breton, Nova Scotia, received from Dr. H. M. Ami, M.A., F.G.S., F.R.S. (Can.).

By Henry Woodward, LL.D., F.R.S., F.G.S.

SOME years ago I published, with the late Professor T. Rupert Jones, F.R.S., a description of two small Limuloids referred to the genus *Bellinurus*, sent me by my friend Dr. H. M. Ami (then of the Canadian Geological Survey), who obtained them from the Lower Carboniferous Marine Series on the Intercolonial Railway of Canada, in Colchester County, Nova Scotia (Geol. Mag., 1899, pp. 387–95, Pl. XV, Figs. 2 and 3), under the specific name of *B. grandævus*. Fig. 2 was collected from the sixth cutting east of Riversdale Station and Fig. 3 from the third cutting east of Colnary River.

Dr. Ami subsequently sent me a further collection of specimens made by him in 1907, from the Carboniferous Series, Glace Bay Mines, Cape Breton, Nova Scotia. Before describing these, however, I venture to give a few notes on the country whence they were obtained, taken chiefly from Dr. Ami's account of Nova Scotia.[1]

Nova Scotia, New Brunswick, and Prince Edward Island form a group of provinces known as "the Maritime provinces", on the eastern flank of the Dominion, and with Newfoundland represent the most approximate land to our shores in North America.

The peninsula of Nova Scotia, 268 miles in length, varying from 60 to 100 miles in width, forms a part of the ancient Acadia, being connected by an isthmus with the Province of New Brunswick at the head of the Bay of Fundy (well known for its high tides), its main axis being from north-east to south-west, and its mountains, with its appendage Cape Breton Island being, geologically, outliers of the Appalachian system on the mainland to the south-west. The northern limit of the Carboniferous system touches the Gulf of St. Lawrence at Miscou Head, and extends in a broad band along all the inner coast of Nova Scotia and into Cape Breton, and comes out near Sydney upon the coast of the Atlantic, where the waves wash the coal-seams on the sea-shore. Carboniferous rocks also occur in the Magdalen Islands and at the south-western point of Newfoundland, where a seam of coal 3 feet thick crops out near the shore.

The Island of Cape Breton is really a continuation of Nova Scotia, from which it is only separated by the Strait of Canso; it is 108 miles long, and contains the important coal-field of Sydney, which extends along the Atlantic shore for 32 miles and covers an area of over 250 square miles. Thirty-four seams occur in this section, but only a few of them have been worked.

Pictou Coal-field, situated on Northumberland Strait, has the finest harbour on the whole north coast of the province. Here the

[1] *Stanford's Compendium of Geography and Travel* (new issue), 1915, North America, vol. i, Canada and Newfoundland; edited by Henry Ami, M.A., D.Sc., F.G.S., F.R.G.S. F.R.S. (Can.); 8vo, 2nd ed. revised, pp. xxviii + 1070.

largest vessels resort to ship coal from the adjacent mines. The field is 35 square miles in extent, and is remarkable for the great thickness of its seams. In one section the main seam is 34 ft. 7 in., and what is known as the deep seam is 22 ft. 11 in. thick. Other seams range from 12 feet, 11 feet, 10 feet, 5 ft. 7 in., 3 ft. 3 in.; in all 107 ft. 10 in. of coal have been recorded in this area.

The Carboniferous formation extends from the high land of Cape George westward along the whole coast of the peninsula bordering Northumberland Strait, and across the country to Chignecto Bay and the Minas Basin, at the head of the Bay of Fundy, occupying Cumberland County and the greater part of Pictou, Colchester, and King's Counties. This forms the Cumberland Coal-field and has an area of 430 square miles, worked chiefly at Springhill, where eight seams occur with an aggregate thickness of 52 ft. 7 in. of coal. Mines have, however, been opened at several other places, as at River Herbert, at Maccan, and at Joggins, whose port and rail-head is at Amherst.

At the Joggins, on the shore of Chignecto Channel, at the head of the Bay of Fundy, is a unique natural exposure of *a continuous section* of Middle and Upper Carboniferous strata, which gave Sir William Logan an actual measurement of 14,570 feet. It is a classic region for geologists, and Sir Charles Lyell, who examined it in 1842, and in 1845, and lastly in 1852, pronounced it to be the finest example in the world of a natural exposure of uninterrupted coal-measures in a continuous section 10 miles long.

The beds, says Lyell,[1] are all seen dipping the same way, their average inclination being at an angle of 24° S.S.W., the vertical height of the cliffs being upwards of 300 feet. He observed seventeen trees in an upright position, or, to speak more correctly, at right angles to the planes of stratification; he counted nineteen seams of coal, varying in thickness from 2 inches to 4 feet. At low tide a fine horizontal section of the same beds is exposed to view on the beach. The thickness of the beds alluded to is about 2,500 feet, the erect trees consisting chiefly of large *Sigillariæ*, occurring at ten distinct levels, one above the other; but Sir William Logan, who afterwards made a more detailed survey of the same line of cliffs, found erect trees at seventeen levels, extending through a vertical thickness of 4,515 feet of strata, everywhere devoid of marine organic remains. The usual height of the buried trees seen by him was from 6 to 8 feet; but one trunk was about 25 feet high and 4 feet in diameter, with a considerable bulge at the base. In no instance could he detect any trunk intersecting a layer of coal, however thin; and most of the trees terminated downwards in seams of coal. Some few only were based in clay and shale; none of them, except Calamites, in sandstone. The erect trees, therefore, appeared in general to have grown on beds of coal. In the under-clays *Stigmariæ* (the *roots* of the *Sigillariæ*) abound.

In 1852 Sir William Dawson and Lyell made a detailed examination of one portion of the strata, 1,400 feet thick, where the coal-seams are most frequent, and found evidence of root-bearing soils at

[1] *Elements of Geology*, 1865, 6th ed., p. 482.

sixty-eight different levels. Like the seams of coal which often cover them, these root-beds, or *old soils*, are at present the most destructible masses in the whole cliff, the sandstones and laminated shales being harder and more capable of resisting the action of the waves and the weather. Originally the reverse was doubtless true, for in the existing delta of the Mississippi those clays in which the innumerable roots of the deciduous cypress and other swamp-trees ramify in all directions are seen to withstand far more effectually the undermining power of the river, or of the sea at the base of the delta, than do beds of loose sand or layers of mud not supporting trees.

As regards the fossil plants (of which Sir William Dawson records over 150 species in the Coal-measures of the South Joggins),[1] they belong to the same genera, and most of them to the same species, as those met with in the distant coal-fields of Europe. Many of the still erect trunks of *Sigillaria* and *Lepidodendron* had their interiors filled up with layers of sandstone, in which Lyell frequently observed fern-leaves, and sometimes fragments of *Stigmaria*, which had evidently entered together with sediment after the trunk had decayed and become hollow, while still standing under water.

When the Carboniferous forests sank below high-water mark a species of *Spirorbis* or *Serpula* attached itself to the outside of the stumps and stems of the erect trees, adhering occasionally even to the interior of the bark—another proof that the process of envelopment was very gradual. These hollow upright trees, covered with innumerable marine annelids, resemble a "cane-brake", as it is commonly called, consisting of tall reeds of *Arundinaria macrosperma*, which Lyell saw in 1846, at the Balize, or extremity of the delta of the Mississippi. Although these reeds are freshwater plants they were covered with *Balani*, having been killed by an incursion of salt water over an extent of many acres, where the sea had for a season usurped a space previously gained from it by the river. Yet the dead reeds, in spite of this change, remained standing in the soft mud, showing how easily the *Sigillariæ* and *Lepidodendron*, hollow as they were but supported by strong roots, may have resisted for some time an incursion of the sea.

The investigation of the organisms preserved in the interior of these hollow trunks of *Sigillariæ*, at the Joggins Coal-measures, by Sir William Dawson, during many years, has resulted in the further discovery of quite a number of new and very interesting forms of terrestrial animals belonging to the Coal period.

Of these we may mention the remains of some small Amphibian reptiles referred to *Dendrerpeton Acadianum* and *Hylonomus Lyelli*, Dawson. To these have been added *Baphetes planiceps*; numerous insect remains, and a Myriopod, *Xylobius sigillariæ*; an air-breathing snail, *Pupa vetusta*, etc.[2]

[1] *Acadian Geology: The Geological Structure, Organic Remains, and Mineral Resources of Nova Scotia, New Brunswick, and Prince Edward Island*, by Sir Wm. Dawson, 8vo, 1868, pp. 694.

[2] "Air-breathing Animals of the Palæozoic Rocks in Canada," by Sir Wm. Dawson, C.M.G., F.R.S.: Trans. Roy. Soc. Canada, 1894.

Bivalve mollusca are extremely abundant in certain shale beds of the Coal-measures, and many have been described and figured by Sir Wm. Dawson, Dr. Wheelton Hind, and others.[1]

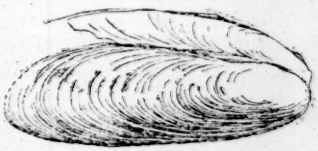

Fig. 1.—*Anthracomya arenacea*, Dawson. ×1½. Found on the same slab with *Euproops Amiæ*, H. Woodw. From Donkin Pit, No. 6. Coal-measures: Glace Bay Mines, Cape Breton, Nova Scotia.

The specimens of Limuloid Arthropods already described by me from Nova Scotia in this Magazine (for September, 1899) were referred to the genus *Bellinurus*; those about to be noticed were also obtained by Dr. Ami, but from the northern extremity of the province at Glace Bay Mines in the Island of Cape Breton, and are referred to the genus *Euproops*. (See Text-figs. 2–4, pp. 466–7, *infra*.)

Order MEROSTOMATA, Dana, 1852.

Sub-order II. XIPHOSURA, Gronovan, 1764.

1. Genus Euproops, Meek & Worthen, 1868, Geol. Surv. Illinois, vol. iii, 1868.

Synonymy.—*Prestwichia* (H. Woodward, 1867), having been preoccupied by Lubbock in 1863 for a genus of Hymenoptera, *Euproops* becomes the type for the following species:—

Euproops Danæ, Meek & Worthen, Geol. Surv. Illinois, vol. iii, 1868.
E. (*Prestwichia*) *anthrax*, H. Woodw., Quart. Journ. Geol. Soc., vol. xxiii, p. 32, pl. i, fig. 2, 1867.
E. (*Bellinurus*) *anthrax*, Bailey, Ann. Mag. Nat. Hist., ser. iii, vol. xi, p. 113, 1863.
E. Colletti, White, Fauna of Indiana Coal-measures, Geol. & Nat. Hist., pl. xxxix, fig. 2, 1883.
E. longispina, Packard, *American Naturalist*, vol. xix, p. 292 (not figured), 1885.
E. (*Limulus*) *anthrax*, Prestwich, Trans. Geol. Soc., ser. ii, vol. v, pl. xii, figs. 1–4, 1840.
E. (*Prestwichia*) *anthrax*, Bolton, Trans. Manchester Geol. Soc., vol. xxxiv, fig. 120, p. ix, 1915.
E. (*Prestwichia*) *Birtwelli*, H. Woodw., Geol. Mag., Vol. IX, p. 440, Pl. X, Figs. 9, 10, 1872.
E. (*Prestwichia*) *Birtwelli*, H. Woodw., Pal. Soc. Mon., *Merostomata*, pt. vi, p. 247, pl. xxxi, figs. 7*a*, *b*, 1878.
E. (*Prestwichia*) *anthrax*, H. Woodward, Pal. Soc. Mon., *Merostomata*, pt. v, p. 244, pl. xxxi, fig. 6, 1878.

Euproops Amiæ, H. Woodw., sp. nov. (Text-figs. 2–4, pp. 466–7.)

The specimens referred to this species consist of an almost complete example and two detached head-shields of a new species of "king-crab", exposed on the surface of three slabs of black-grey shale, associated with specimens of a bivalve mollusc, *Anthracomya*

[1] See Quart. Journ. Geol. Soc., vol. l, pl. xx, fig. 4, 1894 (W. Hind).

arenacea, Dawson (Text-fig. 1), fragments of plant-remains, and some traces of fish-scales.

Like the type of the genus (see *supra*, p. 465) in *Euproops Amiæ*, the head-shield is remarkable by reason of its narrowness from back to front, and the extreme lateral expansion of its cheek-spines, which curve upwards and outwards from the posterior border of the head-shield towards the middle of the cheek before curving downwards to their slender extremities, forming an arc of about 55 mm. measured around the front border of the shield, and 36 mm. along the chord from the extreme points of the cheek-spines, or more than three times as wide as the head-shield is long. The frontal border is narrow and slightly flattened, and the frontal doublure is less strongly marked.

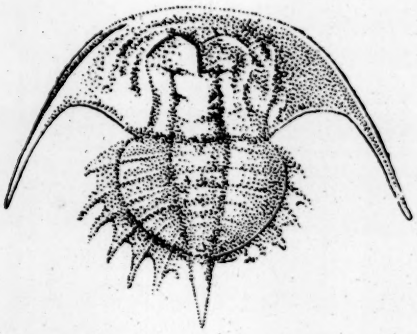

FIG. 2.—*Euproops Amiæ*, H. Woodw., sp. nov. × 1½. (The telson is restored.) Donkin Pit, No. 6. Coal-measures: Glace Bay Mines, Cape Breton, Nova Scotia.

The posterior border of the head where it unites with the thoracetron is 14 mm. broad, but it widens to 29 mm. (including the genal border). The glabella, which is slightly raised, is 10 mm. wide at the cervical border, but slightly widens across the line of the orbits, which are only obscurely to be determined, and is faintly circumscribed by a roundly protuberant rim, within which the glabella forms into a double arch in front, the two arches uniting in a V-shaped backwardly directed ridge in the central line, behind which are three small median lobes marked off by transverse furrows, the hindmost resting on the cervical furrow and the front one extending up to the V-shaped point of the axial ridge. The basis of the glabella ridges gives rise to two backwardly directed slender spines, each 9 mm. in length (these are broken off in Fig. 2, otherwise the most complete specimen, but are seen in the detached head-shields, Figs. 3 and 4). The thoracetron articulates along its anterior border with the posterior margin of the head-shield, which is roundly elevated and cordiform in outline, being 11 mm. broad anteriorly, 16 mm. across at its widest part, and about 25 mm. to the extremity of its lateral marginal spines. The axial division of the cephalon, 5 mm. in width, is continued down the centre of the thoracetron, diminishing gradually to about half that width posteriorly.

The longitudinal furrows of the axis serve to maintain the trilobed character of the whole body. The thoracetron consists of six nearly equal, coalesced segments (the ridge and furrow of each are marked on the central lobe) curving backwards to the margin, and bordered by a stout ridge, which in each segment terminates in a prominent marginal spine (of which there are seven, the seventh forming a part of the rudimentary abdomen); the spines are united to each other by a flat narrow-scalloped border of the shield. The extremity of the axis, composed of two or more coalesced segments and together with the telson or caudal spine (wanting in this specimen), form the rudimentary abdomen: (the telson or tail-spine being absent can only be vaguely estimated from other specimens). There are indications of tubercles along the axial lobe, the base of the largest of which is seen near the termination of the axis over the articulation for the telson.

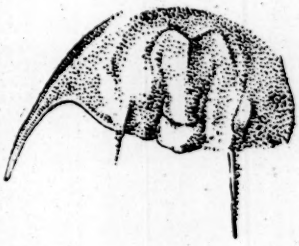

FIG. 3. × 1½.

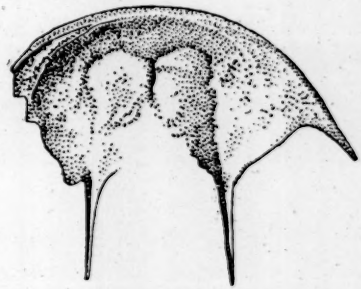

FIG. 4. × 1½.

FIGS. 3 and 4.—Two detached head-shields of *Euproops Amiæ*, H. Woodw., showing long post-cephalic spines from the genal border of the head-shield. From Caledonia Pit, No. 4: Glace Bay Mines, Cape Breton (H. M. Ami, 1907).

Compared with the type of *Euproops* (*E. Danæ*, Meek & Worthen) the head-shield of *E. Amiæ* is deeper from back to front, the free-cheek spines are more laterally divergent and more hollowed out upon their inner posterior border; the axis is broader than in the type, in which the margin of the glabella is somewhat narrower and the eyes are said to be more anteriorly placed; in *E. Amiæ* the posterior border of the glabella, which is rounded, terminates in a pair of slender spines three times as long as those of the type (*E. Danæ*). The thoracetron in *E. Amiæ* is roundly cordiform, and the scalloped marginal border is more definitely separated from it. [As Dr. Meek's specimen is mainly known by his admirable restoration a strict comparison with less perfect materials leaves some points rather doubtful.]

I dedicate this species to its discoverer, my friend Dr. Henry M. Ami, who has devoted many years to the study of Acadian geology.

2. Note on Euproops (Prestwichia) Birtwelli, H. Woodw.

Prestwichia Birtwelli, H. Woodward, Geol. Mag., Vol. IX, p. 440, Pl. X, Figs. 9, 10, 1872.

P. Birtwelli, H. Woodward, Pal. Soc. Mon., *Merostomata*, pt. v, pl. xxxi, figs. 7*a*, *b*, *c*, p. 247, 1878.

After careful reconsideration of this species I have come to the conclusion that the nodules in which these two specimens were enclosed contained only the *central portion* of the body-shields, and that the flat marginal scalloped borders, with their spines, and telson were not preserved as they extended beyond the hard central concretion into the softer external concentric layers of clay (as frequently observed by Dr. Moysey and myself in the clay-ironstone nodules at Shipley, near Ilkeston, Derby, and those also of Rochdale, Lancashire, and Coalbrookdale, Shropshire), and so were not preserved.

The general form of the raised rounded central portion of the body-shield resembles more that of *Euproops* than it does *Prestwichianella*. Assuming the margin to have been furnished with a scolloped border and the segments to have terminated in marginal spines upon the border of the thoracetron, the resemblance to *Euproops Danæ*, *E. anthrax*, and *E. Amiæ* would have been complete.

Formation and Locality.—Coal-measures: Cornfield Pit, south bank of the River Calder, Padiham, Lancashire.

3. Note on the genus Prestwichia, H. Woodw., 1866.

In reference to the genus *Prestwichia* I had for some time been doubtful as to the advisability of retaining the species named *P. anthrax* and *P. rotundata* under the same genus. The investigation of this matter led to the discovery [to which my attention was obligingly drawn by my friend Mr. Charles Davies Sherborn, of the British Museum (Natural History)] of a note which had appeared in the *American Geologist* for 1905, p. 330, by Mr. T. D. A. Cockerell, of the University of Colorado, U.S., that the name *Prestwichia* had been *preoccupied* for a genus of Hymenoptera by Lubbock in 1863, and suggesting the propriety of transferring the species so named to Messrs. Meek & Worthen's genus *Euproops*, 1868. The specimen here referred to was first described in 1865 by Meek & Worthen under the name of *Belinurus Danæ*; later on Mr. Meek assigned his specimen to a new genus between *Belinurus* and *Prestwichia*, for which he proposed the name *Euproops*, in allusion to the anterior position of its eyes.[1]

But although this form, like *Prestwichia*, has the segments of the *thoracetron* anchylosed, *Euproops* differs from it in the quadrangular form of the glabella, and the eyes being situated forward on its anterior lateral angles, while in *Prestwichia* they are borne upon the lateral margins; the genal border must therefore be considered equivalent to the orbital suture, or (most probably) coalesced with it.[2]

[1] F. B. Meek, Amer. Journ. Sci. & Arts, May, 1867. See also Geol. Mag., July, 1867, p. 320, and Geol. Rept. by Meek & Worthen, Survey of Illinois (Palæontology), vol. iii, 1868.

[2] In many of the Trilobita the eye-suture and the axial line of the glabella are *close together*; in young stages of the living American *Limulus* the axial

4. Prestwichianella, gen. nov., 1918.

Prestwichia, H. Woodw., November 21, 1866.
P. rotundata, H. Woodw., Quart. Journ. Geol. Soc., vol. xxiii, p. 32, pl. i, fig. 2, 1866.
Limulus rotundus, Prestwich, Trans. Geol. Soc., ser. II, vol. v, pl. xli, fig. 5, 1840.

Seeing that the name of *Prestwichia*, H. Woodw., was preoccupied by Lubbock in 1863, I now propose to substitute, for the species *P. rotundata*, the new generic name of

Prestwichianella, H. Woodw., gen. nov.[1]

Character amended.[2]—Head-shield semicircular. The genal borders and frontal margin are broad and smooth, and curved roundly on each side towards the thoracetron and ending in moderately broad lateral genal spines; the glabella is divided along the centre by the axial furrow, and by two other slightly diverging parallel lines on either of the axes, reaching nearly half-way to the frontal border, where they are arcaded, forming a rounded raised confluent line in front of the glabella. The circular line seen outside the border of the glabella may indicate the impression of the line of the broad incurved under-margin of the head-shield.

The thoracico-abdominal series of segments are apparently united together into one buckler, as seen in the larval stages of living *Limulus* (see H. Woodward, Mon. Pal. Soc., *Merostomata*, pt. v, pl. xxxiii, figs. 10–12, 1878). Central axis of body-segments narrow; abdomen rudimentary and coalesced with the hindmost thoracic segment, most probably bearing a short telson or tail spine. The broad membranous margin of the thoracetron extends nearly to the extremities of the seven strongly marked spines. Five short spines mark the posterior margin of the head-shield, and some small tubercles along the centre of the posterior axis with a more prominent spine near the base of the telson.

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5. Note on Bellinurus Trechmanni, a new species of Limuloid Arthropod from the Durham Coal-field.

I have been favoured by Mr. C. T. Trechmann, of Castle Eden, Durham, with the loan of a small specimen of a fossil "king-crab", which he lately collected in the highest Coal-measures of the Durham Coal-field at Claxheugh on the Wear, near Sunderland. The beds are in the zone of *Anthracomya Phillipsii*, not generally known to occur in the Durham area, and as they will be shortly described by Dr. Trechmann he kindly permits me to notice this find in advance.

In 1866 I communicated a paper to the Geological Society, "On some points in the Structure of the Xiphosura, having reference to

line and the orbital suture are quite distinct and apart from each other (see Mon. *Merostomata*, pt. v, pl. xxxiii, fig. 10, after Packard; fig. 12, after Dohrn's "*Trilobitenstadium*"). In the adult living *Limulus* the compound eyes occupy the *lateral* border of the glabella.

[1] *P. anthrax* and *P. Birtwelli* are now referred to *Euproops*.

[2] See description in H. Woodward's Monograph on the Merostomata, Pal. Soc. vol., 1878, pt. v, pp. 244–7, pl. xxxi, fig. 5.

their relationship with the Eurypteridæ" : Quart. Journ. Geol. Soc., vol. xxiii, pls. i and ii, p. 32, 1867 ; and again, in my Monograph on the Order Merostomata, Pal. Soc., pt. v, 1878, sub-order Xiphosura, pp. 236–48, I discussed the arrangement of the several genera of these Palæozoic forms of Arthropoda and proposed to divide the Coal-measure species into two genera :—

(A) Those having movable thoracic segments and anchylosed abdominal ones, under the genus *Bellinurus* (with 8 species, 1918).

(B) Those in which all the post-cephalic segments are coalesced under the genus *Prestwichia*. The name being *preoccupied*, it has now been found necessary to subdivide this latter group into two genera, namely : (1) *Prestwichianella*, with 1 species; (2) *Euproops*, with 6 species.

In Section A, *Bellinurus*, König, the earliest records of this genus in which intelligible figures are given are : by Mr. Charles König, Keeper of Geology and Minerals in the British Museum in 1820 (Icones Foss. Sect., pl. xviii, fig. 230), and later, in 1836, by Buckland, in his Bridgewater Treatise, i, p. 396 ; ii, p. 77, pl. xlv, fig. 3 ; Mr. Prestwich, in 1840, Trans. Geol. Soc., ser. II, vol. v, p. 491, pl. xli, fig. 8 ; H. Woodward, 1866, Trans. Glasgow Geol. Soc., p. 247, pl. iii, fig. 10, and Pal. Soc. Mon., *Merostomata* (Xiphosura), pt. v, 1878, p. 236, pl. xxxi, figs. 3*a*, *b*, *c*, and 4.

Genus Bellinurus, König, 1820.

The species included under this genus are :—

Bellinurus bellulus, König, 1820, Icones Foss. Sect.
B. arcuatus, Baily, Ann. Mag. Nat. Hist., ser. III, vol. xi, p. 112, 1863.
B. reginæ, Baily, Ann. Mag. Nat. Hist., ser. III, vol. xi, p. 107, pl. v, 1863.
B. kiltorkensis, Baily, Brit. Assoc. Rep., p. 75, 1869.
B. Kœnigianus, H. Woodw., Geol. Mag., p. 439, Pl. X, Fig. 8, 1872.
B. grandævus, Jones & Woodw., Geol. Mag., 1899.
B. lunatus, Parker, *Lancashire Naturalist*, 1907, p. 44.
B. Baldwini, H. Woodw., Geol. Mag., 1907, p. 540, Fig. 1.
B. longicaudatus, H. Woodw., Geol. Mag., 1907, p. 541, Fig. 2.

Bellinurus Trechmanni, H. Woodw., sp. nov.

Specific Characters. — Head-shield semicircular, being 9 mm. in breadth and 4 mm. in length, the genal spines moderately long, 2½ mm. in length, directed outwards (the extremity is only preserved on one side) ; breadth of glabella 2½ mm., the length is not easily determined but probably about two-thirds that of the head-shield, and there is a faint trace of the arched axis. The frontal border of the head-shield is distinctly marked and the centre is roundly elevated ; the eyes are not distinct ; the posterior border between the spines is fairly straight and measures 7½ mm. The axis of the thoracetron agrees with that of the glabella in breadth (viz. 2½ mm.), only very slightly diminishing towards the telson ; its length is 4 mm. There are six free post-cephalic segments, which are markedly trilobed, directed slightly backwards, ending along the lateral margin in stout recurved spines ; the pleuræ of these free segments diminish rapidly towards the extremity of the thoracetron. There is a small coalesced abdominal portion bearing a tubercle above the insertion

of the stout tail-spine, which is 1 mm. in breadth, but is only imperfectly preserved (length unknown).

There seems to be good evidence that the division (A) of Palæozoic "king-crabs" represented in the Coal-measures by the genus *Bellinurus* contains the oldest form of the Xiphosura, which take precedence, in time, over those with anchylosed segments referred to the division (B) represented by the genera *Prestwichianella* and *Euproops*, as evidenced by their precursor, *Neolimulus falcatus*, H Woodward,[1] 1868.

This *earliest known form* from the Upper Silurian appears to have had *all* its segments free and unanchylosed, and the later form *Bellinurus kiltorkensis*, Baily, from the Old Red Sandstone, probably represents the same genus as is met with in the Coal-measures with free thoracic, and most of them had anchylosed post-thoracic somites.

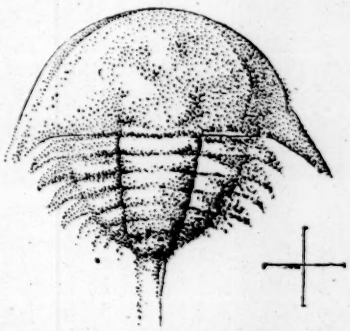


Fig. 5.—*Bellinurus Trechmanni*, H. Woodw., sp. nov. × 4. Upper Coal-measures: Claxheugh on the Wear, Sunderland.

The entire series of species of *Bellinurus* vary little in their general characters. They are all of small size and possessed a long caudal spine and rather marked triangular thoracetron.

The specific characters of the Durham specimen are the obviously shorter and outwardly directed cheek-spines, and the broader and more parallel-sided axis of the thoracetron, which is proportionately larger than in the other species of this genus.

I dedicate this species, which is the first that has been discovered in this great coal-field, to Mr. C. T. Trechmann, whose admirable contributions to the palæontology of New Zealand have already appeared in the pages of the Geological Magazine and elsewhere.

IV.—On the Occurrence of "Coal-balls" near Ambergate, Derbyshire.

By W. D. Varney, B.Sc., University College, Nottingham.

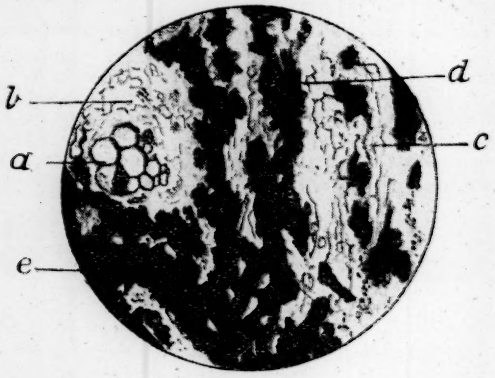
In the brick-pit cut into the Lower Coal-measures at Bullbridge, near Ambergate, the Alton Coal is exposed, immediately overlain by a marine shale roof, containing large nodules (bullions) and marine fossils.

[1] See Geol. Mag., Pl. I, Fig. 1, and Mon. Pal. Soc., 1878, pt. v, *Xiphosura*, pp. 233–5, woodcut, and pl. xxxi, fig. 8.

This succession is similar to that occurring at Shore and other well-known localities in Lancashire, where the Bullion or Upper-Foot Mine contains numerous "coal-balls".

No such concretions have been found and recorded from Derbyshire, but the Alton Coal in the above-named exposure was found to contain large nodules of iron pyrites. Some of these have centres composed of calcite or calcareous material, suggesting that these nodules were originally wholly calcareous.

One of these specimens, on being sectioned, was found to have a centre of calcite containing a Stigmarian rootlet, with the xylem (*a*) fairly well preserved surrounded by the cortex (*b*), which, though in a poor state of preservation, is still quite recognizable. Other parts of the section contained plant tissue badly preserved, and partly obscured by pyrites. Pyritization seems to have taken place along lines of tissue running through the calcite groundmass as seen at (*d*) and (*c*) in the diagram and in other parts of the slide.



Section of nodule showing plant-tissues (somewhat diagrammatic). *a*, xylem of Stigmarian rootlet; *b*, cortex; *c*, *d*, other tissue, partly hidden by pyrites (*e*).

At Bullbridge the Alton Coal is streaked with pyrites, which fills cracks and joints, and the thin veins often join on to the nodules of the same material. Hence the pyrites was deposited after the formation of the seam and its nodules. This fact, and the features of the nodule section described, show that the pyrites is secondary, and that the calcite and its petrified plant tissue were deposited before the pyrites, which has replaced the former and largely obliterated the vegetable tissue in so doing. In other words the nodules were true "coal-balls", now partly or wholly replaced by iron pyrites.

Hence the Alton Coal of Derbyshire contains nodules with petrifactions, though they are mostly altered to iron pyrites. Thus the seam shows a striking resemblance to the Bullion Seam of Lancashire, as described by Miss Stopes and D. M. S. Watson.[1]

[1] "On the Present Distribution and Origin of Coal-balls": Proc. Roy. Soc., vol. cc, p. 173.

A rough analysis of the specimen sectioned showed that it contained, in addition to iron pyrites, calcium and magnesium carbonates and calcium sulphate, the last-named being present in sufficient quantity to form a thick efflorescence when the nodule had been kept for some time. This calcium sulphate is confined to the coal and its marine roof, where it is also abundant,[1] and to these two beds only, so that its occurrence seems intimately connected with the latter bed.

A new locality, therefore, can be cited for the occurrence of "coal-balls" or their equivalents, namely, the Alton Coal of Derbyshire, particularly near Ambergate, under conditions which help to confirm the theories enunciated by Professor Stopes and D. M. S. Watson,[2] namely, that in whatever coal tissue-bearing nodules occur, that coal is overlain by a roof of marine origin, and that the formation of these nodules was contemporaneous with that of the surrounding coal.

REVIEWS.

I.—Summary of Progress of the Geological Survey of Great Britain for 1917. 55 pp. London, 1918. Price 2*s*.

IT is a noteworthy sign of the times that this summary of the year's work of the Geological Survey deals almost exclusively with matters of practical and economic interest. The depleted staff has given evidence of great activity, and an immense amount of useful information has been collected, with the assistance of certain specialists who were temporarily attached to the Survey. The most important work carried out was an investigation into the reserves of iron-ore still existing in Great Britain. Every possible iron-field seems to have been very thoroughly examined, and it is estimated that the grand total of ores of all kinds amounts to no less than 11,311,000,000 tons. However, much of this is of very low grade and unlikely to be worked for some time to come.

The subject of refractories has also engaged much attention and a comprehensive memoir on the subject is in course of publication. The increased demand for tungsten ores has brought about important developments in Cornwall and Devon and new lodes have been reported on. A special examination was also made of Scottish pegmatite dykes as possible sources of potash felspar for pottery, enamel, and other purposes. A magnetic survey of certain parts of England was undertaken with the object of ascertaining whether certain observed disturbances of the magnetic needle were due to concealed masses of iron-ore; a report on the subject is in preparation. The proposal to construct a ship-canal across Scotland has necessitated investigation of the depth of drift and other superficial deposits along the proposed lines, with interesting results. Good progress has also been made with the publication of memoirs on the Scottish coal-fields.

[1] R. D. Vernon, Geol. Mag., 1909, p. 289.
[2] Ibid., p. 181.

Three appendices contain accounts of the results of deep borings at Market Weighton, Newark, and Hitchin respectively. The first of these shows that the Trias and Permian do not thin away north of the Humber, as was hoped; the boring was stopped in Lower Permian Limestone at 3,100 feet from the surface. The boring at Kelham, near Newark, reached the Coal-measures at 1,401 feet, and penetrated to the Carboniferous Limestone Shales. Only 148 feet of strata can be assigned to the Millstone Grit, hence the boring probably passed through at least one fault. The Hitchin boring appears to indicate a thickness of 250 feet of drift near the western margin of the drift-filled channel already known to exist in that neighbourhood.

R. H. R.

II. — British Museum Return, 1917. Published by H.M. Stationery Office, London, 1917. Price 6*d*.

THIS report as usual contains a large amount of interesting information as to the progress of the various departments of the British Museum, together with the accounts of the special trust funds. The number of visitors at Bloomsbury naturally shows a great falling off, since for ten months out of the twelve the galleries were closed to the public. At South Kensington most of the galleries remained open during the year 1916 and the number of visitors was nearly as large as usual, amounting to 402,673. The staff carried out for the Government a large number of investigations on subjects directly connected with the War, as well as other special work of a more normal kind, and various topical exhibits have been arranged. The number of new acquisitions is somewhat smaller than usual, as might be expected, but the general routine work of the Museum has suffered little or no interruption, and the publication of serial reports has been continued. A large number of valuable fossils have been presented to the Department of Geology, of which the most important are perhaps those comprised in the Hamling Collection from Devonshire, while the Department of Mineralogy has also acquired many specimens of interest, including several meteorites from various falls not hitherto represented in the collection.

III.—The Work of Local Societies and Museums.

IN spite of the adverse conditions of the present time as regards scientific work on subjects not directly connected with the War, it is gratifying to note that many local societies seem to pursue the even tenour of their way with little visible disturbance. For example, the fifty-first Report of the Rugby School Natural History Society for the year 1917 contains evidence of great keenness and enthusiasm among the members, who are carrying out useful observational work of several kinds, zoological, botanical, geological, and meteorological. The section of physics and chemistry has also been active, and the report contains reprints of two interesting

papers by members, on the fixation of atmospheric nitrogen and on saccharine respectively.

The first part of the third volume of the *Hastings and East Sussex Naturalist*, the organ of the Hastings and St. Leonards Natural History Society, also shows evidence of much activity on the part of that Society. It contains two papers of geological interest. The first of these, by Mr. Anthony Belt, is entitled "Prehistoric Hastings", and comprises a very full account of the geological history of that interesting district, from the Wealden to the Roman occupation. Most space is devoted to the later phases, and special attention is paid to the history and development of man, as is only natural in a district so near to the home of *Eoanthropus Dawsoni*. Another valuable contribution is a paper on the Brighton Rubble-Drift formation, by Mr. E. A. Martin. This, though short, gives a very good description of this peculiar and interesting formation, illustrated by photographs.

The annual report of the Norwich Castle Museum for 1917 shows that the Museum was the centre for the dissemination of much useful information, and the fact that it was visited by no less than 132,751 persons shows that it has succeeded in fostering a widespread interest in historical and scientific subjects.

IV.—British Supplies of Potash Felspar, considered from the Glass-making Point of View. By Professor P. G. H. Boswell, D.Sc., F.G.S. Trans. Soc. Glass Technology, vol. ii, pp. 35–71, with 1 plate and 4 figures. 1918.

POTASH-FELSPAR for use in the pottery and glass industries should satisfy the following requirements:—

1. High content of potash, if possible more than 10 per cent and certainly not less than 8 per cent.

2. Low content of soda; preferably none and certainly not more than 2 per cent.

3. Low content of quartz, not more than 5 per cent for the best pottery, and not in excess of 20 per cent for inferior pottery. In glass-making the quartz does no harm, but it can be bought at a lower rate than felspar.

4. The amount of iron oxide should be small, and in the best pegmatites the percentage falls below 0·1.

5. Lime should not exceed 0·5 per cent.

6. The rock must be fresh, or there will be a considerable loss of potash owing to kaolinization of the felspars.

It may be mentioned that 13 and 9 per cent of potash correspond respectively to 77 and 53 per cent of microcline or orthoclase, and 3 and 1 per cent of soda to 25 and 9 per cent of albite.

More or less workable deposits of potash-bearing felspar in the form of pegmatites occur in many localities in the British Isles. These are Tresayes, Trelavour Downs, Kernick, and Luxulyan in Cornwall; in Sutherland, between Lochs Laxford and Inchard, between Durness and Eireboll and near Overscaig, Strontian

(Argyllshire), Portsoy (Banff), and Monymusk (Aberdeenshire); near Belleek, on the borders of co. Donegal and co. Fermanagh, in the Glenties area of co. Donegal, and the Bellmullet area of co. Mayo.

Felspars of the best quality (grade 1) occur in Cornwall at Tresayes, Kernick, and Trelavour, and in the neighbourhood of Belleek in Ireland. These occurrences are all situated fairly near to road, railway, and the sea, but the quantity in each case is limited. Each area yields hand-picked material suitable for the best glass and pottery work, showing from 10 to 13 per cent K_2O, but none of them can be worked on the large scale for the extraction of potash.

Round Rhiconich and near Durness in Sutherland, on Erris Head near Bellmullet, and on the Gweebarra River in co. Donegal there are millions of tons of pegmatite of grades 2 and 3. These, however, would not yield more than 8 or 9 per cent of potash after hand-picking, and are almost unworkable on account of their inaccessibility. These large deposits might possibly be worked for the extraction of their potash, but the operations would have to be conducted on very efficient lines for such a project to be payable, the chief difficulty being the shipping of the felspar, on account of the distance of the deposits from available harbours.

The supplies of high-grade spar in the Cornish and Belleek areas might be sufficient for the requirements of our industry for a limited time, but not for any considerable period, owing to the small reserves available. Certain felsites near Wicklow and Waterford and some Cretaceous glauconitic sands have been suggested as sources of potash, but unfortunately their potash content is in most cases much too low and never sufficiently high to render them worth working.

The paper is furnished with numerous analyses of the felspars and pegmatites, including some foreign as well as the British examples. It represents a very considerable amount of work, since the author has visited all the localities which he describes, some of which, being situated in the wildest parts of north-west Scotland and the west of Ireland, are very difficult of access.

W. H. W.

V.—British Resources of Sands and Rocks used in Glass-making.[1] By Professor P. G H. Boswell. Second and complete edition. pp. xi + 170, with 10 plates and 13 figures in the text. London: Longmans, Green & Co. 1918.

IN this second edition the author's two earlier memoirs on British glass sands are combined into one volume. A few parts have been rewritten and some further information has been added, but otherwise most of the matter is the same. The book in its present form is a comprehensive survey, not only of British glass sands, but of the more important foreign occurrences, and also of other deposits essential to the glass industry, such as those of potash and alumina.

W. H. W.

[1] See also Geol. Mag., March, 1918, p. 131.

VI.—On the Splitting of Coal Seams by Partings of Dirt. Part I: Splits that Rejoin. By P. F. Kendall. Trans. Inst. Min. Eng., vol. liv, p. 460, 1918.

THE explanation of the splitting of coal-seams that has so long done duty in text-books is unsatisfactory and often inapplicable to actual instances, since it is frequently found that the upper portion of the split seam is convex upwards while the lower portion is horizontal. Professor Kendall has made a careful study of split seams in the Yorkshire coal-field, especially in the Silkstone or Middleton Main and Haigh Moor seams at Whitwood, Ackton Hall, Methley, and South Kirkby. The explanation put forward depends on the well-known fact that peat on conversion to coal undergoes a very great reduction in volume, here estimated at 20 to 1. A trough-like wash-out in a bed of peat, filled with sand or mud, would be much less compressed than the peat; the whole mass would settle down in a ridge-like form with a thin layer of coal above and below the sandstone or shale, the form of the mass thus undergoing inversion in cross-section.

By mapping the known position of the edges of split seams it has been found possible to trace out the courses of Carboniferous rivers over distances of several miles, and the method of investigation pursued seems likely to lead to results of great practical and scientific interest.

R. H. R.

VII.—Some Problems of Western Australian Geology. Presidential Address to the Royal Society of Western Australia, delivered on July 11, 1916, by A. Gibb Maitland, F.G.S. pp. 34, with 38 figures. Perth, 1917.

IN this presidential address the author deals chiefly with the Nullagine formation. This series of rocks has a very wide distribution in the state, and is composed chiefly of sandstones, quartzites, conglomerates, dolomitic limestones and igneous rocks, dolerite dykes and sills, with lavas and ashes at one horizon. The series, the lower members of which are gold-bearing, rests with a very marked unconformity on the underlying rocks, which are everywhere metamorphosed and of pre-Cambrian age. The sequence begins with a basal conglomerate, which is followed by an outbreak of lavas and ashes, chiefly andesitic, but in places rhyolitic, which appear to have been produced by fissure eruptions, as few volcanic foci have been discovered. These rocks are followed by dolomitic limestones, which are in turn overlaid by a sandy series with hæmatite and magnetite, bearing quartzites or jaspers, having sometimes as much as 37 per cent of iron. The ferruginous bands are thin and interbedded with light-coloured quartzites, so that a banded rock is produced.

The dolerite sills are of very uniform composition and do not seem to have undergone much metamorphism since their intrusion; they are accompanied in the more disturbed areas by quartz reefs with gold and copper. The reservoir which supplied this igneous material seems to have been situated about latitude 26° S. There

are several points which require elucidation in connexion with this formation; firstly, the age is very uncertain, the rocks were affected by pre-Permo-Carboniferous folding and rest on crystalline schists; H. P. Woodward thought they were Devonian, but this cannot be proved in the absence of fossils. Again, it is not clear whether the igneous rocks of the intrusive phase followed closely on those of the volcanic phase or not. Finally, the ore-bearing rocks of Western Australia are all more or less associated with the Nullagine formation, but it is uncertain whether the mineralization was associated with the pre-Cambrian mountain-building movements which produced the metamorphism in the older rocks or whether it took place after the deposition of the Nullagine formation.

W. H. W.

VIII.—An Exploration of the Tazin and Taltson Rivers, North-West Territories. By Charles Camsell. Geological Survey of Canada, Memoir 84. pp. iii + 124, with 18 plates and map. Ottawa, 1916.

IN the North-West of Canada there are still vast tracts of country which are as yet unexplored; one of the largest of these "blocks" forms the subject of this communication. The region is situated between the Great Slave Lake and Lake Athabasca; it is part of the Laurentian plateau region and abounds in lakes, while its rivers flow in irregular valleys which are rarely more than 100 feet deep.

The oldest rocks, which occur now in isolated patches, are "a series of schists, quartzites, conglomerates, limestones, argillites, and some volcanic rocks", which are grouped together under the name of the Tazin Series. These are Archæan rocks, probably Huronian in age. The Tazin Series is invaded by a great composite batholith of gneisses and granites with some quartz diorites. These rocks, which occupy the greater part of the area, have a north and south trend, corresponding more to the Cordilleran lines than to those of Eastern Canada. At one place, at the north-east end of Tazin Lake, there is a remnant of the Athabasca Sandstone, which is a conglomeratic deposit of Keweenawan age, and probably of terrestrial origin. After this rock there is a complete absence of any deposit till those of the Pleistocene glaciation. The glaciation in this region was very intense, as is shown by the rounded, grooved, and striated character of the rocks, and by their fresh and unweathered condition. Glacial deposits, boulder-clay, moraines, drumlins, and sand plains are found, but not in any great abundance, the rock being mostly left bare of any surface deposit. The direction of motion of the ice as shown by the striæ seems to have been about S. 62° W., while there is evidence of a later feebler glaciation with a more northerly trend. The Tazin Series is cut by numerous quartz veins which contain pyrites in places, and seem to offer some prospects of valuable metalliferous deposits. The memoir contains also a detailed account of the canoe routes followed by the author, and is illustrated by many excellent photographs of the country.

W. H. W.

IX.—Frozen Muck in the Klondike District, Yukon Territory, Canada. By J. B. Tyrrell, F.R.S.C. Trans. Roy. Soc. Canada, ser. III, vol. IX, pp. 39–46, with 3 plates, 1917.

THE valley floors of the Klondike District are the products of the third cycle of erosion since the last continental uplift of the region. In the Miocene period the Dome peneplain was produced by the first cycle of erosion. In Pliocene times the valleys in which the older White Channel gravels were deposited were carved out during the second cycle of erosion, while the present valleys and their alluvial gravels are connected with the third cycle, which lasted till the end of the Pliocene period. During this time the climate was temperate and the country was inhabited by a number of the larger mammals, but at the beginning of the Glacial period different conditions set in, and, though this region was not covered by an ice-sheet, the soil was certainly frozen all the year round. In consequence of this the alluvial gravels and the beds of the streams became impervious to water and resistant to erosion. When, therefore, the snow melted in the spring the water in the stream channels brought down, instead of sand and gravel, only vegetable debris from the hill-sides, which collected on the alluvial flats and was held fast and preserved by the large growth of bog mosses. In this way great thicknesses of this frozen bog or "muck" were accumulated, varying from 2 to 40 feet and even 100 feet in the narrower gulches, which have to be sunk through before the gold-bearing gravels can be worked. "Muck" is also found in the form of frozen bogs on the hill-sides, where it often contains layers of clear ice, tilted at steep angles by the slipping of the bog. The "muck" now forms the upper part of the valley deposits, which shows that little or no gravel has been transported since the beginning of the period of perennial frost, and that, therefore, the valley gravels are all pre-Glacial in age.

CORRESPONDENCE.

ON *TEREBRATULA GRAYI*, DAVIDSON.

Sir,—In a former paper in this Magazine (Dec. VI, Vol. III, pp. 21–6, 1916) I proposed the name *Thomsonia* for the *Terebratula grayi* of Davidson. This name, I find, has unfortunately been used for Insecta on two previous occasions, viz. in 1879 and 1884, and, therefore, cannot stand. In its place I now propose

Coptothyris, gen. nov.

Coptothyris grayi has been placed in *Waldheimia* (now *Magellania*) and in *Dallina* by various authors, on account of the loop having reached the highest developmental stage in the Terebratellidæ; but it is distinct from either of these genera on other grounds. The full details of these differences are reserved for a future paper on the cardinalia of the Dallininæ in general. In this paper I hope to show that the cardinalia (or hinge-processes of the dorsal valve) of the sub-family Dallininæ can be readily differentiated into, at least,